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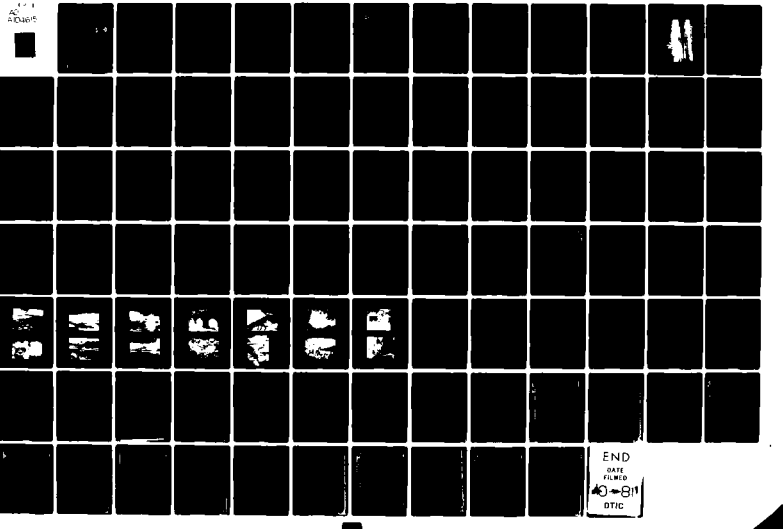

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GRAND·CHARITON RIVER BASIN

WATER WORKS LAKE DAM
RANDOLPH COUNTY MISSOURI
MO. 10006

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

PREPARED BY: U. S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

NOVEMBER 1979

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1. REPORT NUMBER	2. GOVT ACCESSION NO. A104615 / 3. RECIPIENT'S CATALOG NUMBER
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7. AUTHOR(s) Consoer, Townsend and Associates, Ltd. (Walter G. Shirvin)	8. CONTRACT OR GRANT NUMBER(s) DACW43-79-C-0075 ✓
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS //
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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

SUBJECT: Water Works Lake Dam (Mo. 10006) Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Water Works Lake Dam (Mo. 10006).

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

1) Spillway will not pass 50 percent of the Probable Maximum Flood
2) Overtopping could result in dam failure
3) Dam failure significantly increases the hazard to loss of life downstream

SUBMITTED BY: SIGNED — Chief, Engineering Division — 26 DEC 1979 — Date

APPROVED BY: SIGNED — Colonel, CE, District Engineer — 28 DEC 1979 — Date

WATER WORKS LAKE DAM
RANDOLPH COUNTY, MISSOURI

MISSOURI INVENTORY NO. 11017

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY
CONSOER, TOWNSEND AND ASSOCIATES, LTD.
ST. LOUIS, MISSOURI
AND
ENGINEERING CONSULTANTS, INC.
ENGLEWOOD, COLORADO
A JOINT VENTURE

UNDER DIRECTION OF
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
FOR
GOVERNOR OF MISSOURI

NOVEMBER 1979

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam: Water Works Lake Dam, Missouri Inv. No. 10006
State Located: Missouri
County Located: Randolph
Stream: An Unnamed Tributary of Sweet Spring Creek
Date of Inspection: June 13, 1979

Assessment of General Condition

Water Works Lake Dam was inspected by the engineering firms of Consoer, Townsend and Associates Ltd. and Engineering Consultants, Inc. (A Joint Venture) of St. Louis, Missouri using the "Recommended Guidelines for Safety Inspection of Dams". These guidelines were developed by the Chief of Engineers, U.S. Army, Washington, D.C., with the help of Federal and State agencies, professional engineering organizations, and private engineers. The resulting guidelines are considered to represent a consensus of the engineering profession.

The overall structural condition of the dam does not appear to be entirely satisfactory. The dam does not exhibit signs of structural instability, however, the seepage located 36 feet upstream of the downstream end of the service spillway channel does pose a potential danger to the structural stability of the dam. The seepage should be investigated with high priority and repaired

as required. The dam appears to be adequately maintained.

Based on the criteria in the guidelines, the dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur in the event of failure of the dam. The estimated damage zone extends about one and one-half miles downstream of the dam. Within the damage zone are eight dwellings, one pumphouse, a sewage disposal plant, and several improved road crossings which may be subjected to flooding, with possible damage and/or destruction, and possible loss of life. The Water Works Lake Dam is in the small size classification since it is less than 40 feet high and impounds less than 1,000 acre-feet of water.

Our inspection and evaluation indicates that the spillway of Water Works Lake Dam does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. Water Works Lake Dam being a small size dam, with a high hazard potential, is required by the guidelines to pass from one-half of the Probable Maximum Flood to the Probable Maximum Flood without overtopping. Since there is a high hazard potential downstream of the dam, the appropriate spillway design flood for this dam is the Probable Maximum Flood. It was determined that the reservoir/spillway system can accommodate only 9 percent of the Probable Maximum Flood without overtopping the dam. Our evaluation indicates that the reservoir/spillway system will accommodate the 10-year flood without overtopping the dam. However, the dam will be overtopped during the occurrence of the 100-year flood.

The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in the region. The 100-year and the 10-year floods are defined as the floods having a 1 percent and a 10 percent

chance, respectively, of being equalled or exceeded during any given year.

Other deficiencies noted by the inspection team were: the undercutting of the downstream end of the service spillway channel; the vegetation around the intake and outlet of the emergency spillway; the erosion of the upstream crest and slope due to wave action and storm runoff; the vegetation and several trees on the upstream slope and the one large tree on the downstream slope; a lack of periodic inspection by a qualified engineer and a lack of maintenance schedule. The lack of seepage and stability analyses on record is also a deficiency.

It is recommended that the owner take action to correct or control the deficiencies described above.

Walter G. Shifrin, P.E.

Overview of Water Works Lake Dam

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

WATER WORKS LAKE DAM, I.D. No. 10006

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Water Works Lake Dam, Missouri Inv. No. 10006

SECTION 1: PROJECT INFORMATION

1.1 General

a. Authority

The Dam Inspection Act, Public Law 92-367 of August, 1972, authorizes the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspections. Inspection for Water Works Lake Dam was carried out under Contract DACW 43-79-C-0075 to the Department of the Army, St. Louis District, Corps of Engineers, by the engineering firms of Consoer, Townsend & Associates Ltd., and Engineering Consultants, Inc. (A Joint Venture), of St. Louis, Missouri.

b. Purpose of Inspection

The visual inspection of Water Works Lake Dam was made on June 13, 1979. The purpose of the inspection was to make a general assessment as to the structural integrity and operational adequacy of the dam embankment and its appurtenant structures.

c. Scope of Report

This report summarizes available pertinent data relating to the project; presents a summary of visual observations made during the field inspection; presents an assessment of hydrologic and hydraulic conditions at the site; presents an assessment as to the structural adequacy of the various project features; and assesses the general condition of the dam with respect to safety.

Subsurface investigations, laboratory testing, and detailed analyses were not within the scope of this study. No warranty as to the absolute safety of the project features is implied by the conclusions presented in this report.

It should be noted that reference in this report to left or right abutment is as viewed looking downstream. Where left abutment or left side of the dam is used in this report, this also refers to north abutment or side, and right to the south abutment or side.

d. Evaluation Criteria

Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams", Appendix D. These guidelines were developed with the help of several Federal agencies and many State agencies, professional engineering organizations, and private engineers.

1.2 Description of the Project

a. Description of Dam and Appurtenances

It should be noted that design drawings are not available for the dam or appurtenant structures. The following description is based exclusively on observations and measurements made during the visual inspection.

The dam consists of an earthfill embankment between earth abutments. The crest width is 26 feet, with a length of approximately 400 feet. The crest elevation varies from 814.5 feet above MSL on the right abutment to 808.4 feet above MSL on the left abutment. The maximum height of the embankment was measured to be 30 feet.

The downstream slope of the embankment was measured to be 1V to 2.75H. However, the slope is being flattened by occasional dumping of random materials. The upstream slope of the embankment was measured to be 1V to 1.5H. No riprap protection was observed on the upstream slope.

There are two spillways for the Water Works Lake Reservoir. The service spillway is cut into the left abutment. The spillway is a trapezoidal shaped gunite-lined, open channel with side slopes of 1V to 1.25H, and a bottom width varying from a minimum of 12 feet to a maximum of 19 feet. The channel is approximately 120 feet long. A hinged metal trashrack is located on the upstream side of the spillway. The emergency spillway consists of two 27-inch diameter concrete pipes through the embankment. The 27-inch concrete pipes are located near the right abutment. The spillway conduits are each about 58 feet long with no slope and discharge into an earth cut channel.

A 10-inch ductile iron outlet pipe passes beneath the embankment near the left abutment to a pumphouse located just downstream of the dam. The inlet invert can be raised or lowered by a winch which is mounted on a steel tower located in the reservoir. The outlet is controlled by a gate valve in the pumphouse. There are two pumps in the pumphouse, one is diesel powered and one is driven by electricity.

The dam is situated in the Dissect Till Plains section of the Central Lowlands Province (Fennemen, N.M., "Physiography of Eastern United States", 1946). This area was glaciated during Pleistocene time, at the close of which relatively thick deposits of glacial till were deposited on the underlying bedrock.

Regionally, in the dam area, the rocks are dipping gently to the southwest at about 25 feet per mile ("Structural Features Map of Missouri", 1971). The dam is situated on the southwest flank of the College Mound - Bucklin Anticline, a major structure whose northwest striking axis is 10 miles to the northeast. At the dam site, the beds are essentially flat lying.

b. Location

The Water Works Lake Dam is located on an unnamed tributary of Sweet Spring Creek, Randolph County, Missouri. The dam is located in the southwest corner of Rothwell Park, which is on the west side of Moberly, Missouri. The dam and the reservoir are shown on the Moberly, Missouri Quadrangle Sheet (7.5 minute series) northeast 1/4 of the southeast 1/4 of Section 3, Township 53 North, Range 14 West.

c. Size Classification

According to the "Recommended Guidelines for Safety Inspection of Dams", by the U.S. Department of the Army, Office of the Chief Engineer, the dam is classified in the dam size category as being "Small" since its storage is less than 1,000 acre-feet. The dam is also classified as "Small" in dam size category because its height is less than 40 feet. The overall size classification is, accordingly, "Small" in size.

d. Hazard Classification

The dam has been classified as having "High" hazard potential in the National Inventory of Dams, on the basis that in the event of failure of the dam or its appurtenances, excessive damage could occur to downstream property, together with the possibility of the loss of life. Our findings concur with the classification. The estimated damage zone extends about one and one-half miles downstream of the dam. Within the damage zone are eight dwellings, one pumphouse, a sewage disposal plant and several improved road crossings.

e. Ownership

The Water Works Lake Dam is owned by the City of Moberly, Parks and Recreation Department. The mailing address is The City of Moberly, Parks and Recreation Department, c/o Mr. Jerry Calvin, 109 North Clark Street, Moberly, Missouri, 65270.

f. Purpose of Dam

The purpose of the dam is to impound water for recreational use by the Parks and Recreation Department, and as a possible supplemental water supply for the city.

g. Design and Construction History

Water Works Lake Dam was originally built about 1870. Exact dates and information are not available, however, according to Mr. Don Tuley, the City Engineer, the dam may have been built under the direction of the Moberly Board of Public Works.

The gunite lining of the service spillway was added in 1967 after a rainstorm washed out a portion of a park road directly east of the spillway. The lining was provided to help channelize any water which was flowing through the spillway.

The emergency spillway located near the right abutment was constructed in 1960 by city crews in hopes of raising the reservoir level by raising the dam and plugging up the present service spillway. This project was never completed and the lake remains at its original level.

The pumphouse was constructed in 1911 and the two water pumps inside were in constant service for about 11 years until they were taken out of service in 1922 because of the expansion of the Sugar Creek Project located north of Moberly.

h. Normal Operational Procedures

There are no specific operational procedures for Water Works Lake Dam. The water level is controlled by rainfall, runoff, evaporation, and the spillway crest elevation. The reservoir level is allowed to remain as full as possible. Prior to 1922, the reservoir was maintained as a water supply lake, but is now operated for recreational use.

1.3 Pertinent Data

a. Drainage Area (square miles): 0.65

b. Discharge at Damsite

Estimated experienced maximum flood (cfs):	80
Estimated ungated spillway capacity at maximum pool elevation (cfs):	135

c. Elevation (Feet above MSL)

Top of dam:	Varies from 814.5 on the right abutment to 808.4 on the left abutment.
Spillway crest:	
Service Spillway	806.0
Emergency Spillway	808.7 *
Normal Pool	806.0
Maximum Pool (PMF):	812.68

d. Reservoir

Length of maximum pool (Feet):	2800

e. Storage (Acre-Feet)

Top of dam:	201
Spillway crest:	
Service Spillway	147
Emergency Spillway	206 *
Normal Pool:	147
Maximum Pool (PMF):	350

* Higher than top of dam (according to field measurement)

f. Reservoir Surface (Acres)

Top of dam:	24
Spillway crest:	
Service Spillway	21
Emergency Spillway	24± *
Normal Pool:	21
Maximum Pool (PMF):	31±

g. Dam

Type:	Earthfill
Length:	400 feet
Structural Height:	30 feet
Hydraulic Height:	24 feet
Top width:	26 feet
Side slopes:	
Downstream	1V to 2.75H
Upstream	1V to 1.5H
Zoning:	Unknown
Impervious core:	Unknown
Cutoff:	Unknown
Grout curtain:	Unknown

h. Diversion and Regulating Tunnel None

* Higher than top of dam (according to field measurement)

i. Spillway

Type:	
Service Spillway	Open Channel, Uncontrolled
Emergency Spillway	Conduit, Uncontrolled *
Length of weir:	
Service Spillway	12 feet
Emergency Spillway	2-27-inch diameter concrete pipes
Crest Elevation (feet above MSL):	
Service Spillway	806
Emergency Spillway	808.7 *

j. Regulating Outlets

Type:	10-inch diameter ductile iron water supply pipe
Length:	Unknown
Closure:	Gate Valve
Maximum Capacity:	*Unknown*

* Higher than top of dam (according to field measurement)

SECTION 2 : ENGINEERING DATA

2.1 Design

No design drawings or data are available for Water Works Lake Dam. It is doubtful if any plan or design exists for the structure.

2.2 Construction

No construction records or data are available for the dam and appurtenant structures, other than the construction history given in Section 1.2g.

2.3 Operation

No operation records are available for the Water Works Lake Dam.

2.4 Evaluation

a. Availability

The availability of engineering data is poor. The available data consist only of State Geological Maps, U.S.G.S. Quadrangle Sheets and the data given in the National Dam Inventory Table. No information on subsurface investigations or soil testing was available. No information on design hydrology or hydraulic design was available, nor were seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams", which

is considered a deficiency.

b. Adequacy

The conclusions presented in this report are based on field measurements, past performance and present condition of the dam. The data available is inadequate to evaluate the hydraulic and hydrologic capabilities of the dam. In the absence of seepage and stability analyses no quantitive evaluation of the structural stability can be made. These seepage and stability analyses should be performed for appropriate loading conditions and made a matter of record.

c. Validity

Not applicable, as no design or construction records were available.

SECTION 3: VISUAL INSPECTION

3.1 Findings

a. General

A visual inspection of the Water Works Lake Dam was made on June 13, 1979. The following persons were present during the inspection:

Name	Affiliation	Disciplines
David J. Kerkes	Engineering Consultants, Inc.	Soils Engineer
Peter Howard	Engineering Consultants, Inc.	Geology
Mark R. Haynes	Engineering Consultants, Inc.	Civil, Structural & Mechanical
Kenneth L. Bullard	Engineering Consultants, Inc.	Hydraulics & Hydrology
Kevin Blume	Consoer, Townsend & Assoc., Ltd.	Civil and Structural
Oran Patrick	City of Moberly, Missouri	Superintendent of Parks & Rec.
Ron Wilson	City of Moberly, Missouri	Director of Public Works

Specific observations are discussed below.

b. Dam

The crest of the dam has an adequate cover of vegetation which protects the embankment materials. There was no evidence of significant settlement or cracking on the crest. No significant deviations in horizontal or vertical alignment were apparent. The elevation on the right abutment is approximately 6 feet higher than the left abutment. According to Mr. Wilson, the dam has no history of being overtopped.

The upstream embankment slope does not have riprap protection. Some erosion has occurred near the water surface due to wave action. This has caused some steepening of the embankment slope, with the slope appearing to be near vertical in some areas. Some erosion has occurred due to storm runoff along bare areas which are used for paths. Heavy vegetation and several large trees are growing along most of the slope. No depressions or settlements were observed on the slope.

The downstream embankment slope has patchy grass cover and one large tree. Random materials are being dumped on the downstream slope to flatten it. The random material consists of various types of soil, bricks and other types of materials not normally used for embankment materials. No seepage was observed along the toe of the slope, however, seepage was observed flowing at the contact of the downstream embankment and the right side of the discharge channel of the service spillway. The seepage was located at approximately 36 feet upstream of the downstream end of the gunite lining on

the right side of the discharge channel. The rate of flow of the seepage was not determined because of the inaccessibility and quantity of flow, but, the seepage was considered to be significant since it has eroded some embankment material and was causing the material above it to cave in. Nevertheless, the discharge was clear at the time of the inspection. It was undetermined whether the seepage was flowing along the embankment and abutment contact, through the embankment or through the foundation. No depressions, bulges or settlements were observed on the downstream slope. According to Mr. Patrick, he was not aware of any sloughing or seepage on the downstream slope in the past. Materials removed immediately below the vegetation cover on the embankment appeared to be a clayey silt.

Both abutments appeared to be natural earth material with adequate protection. The left abutment, some 50 feet from the embankment contact, was measured to be 6 inches below the crest of the dam. From there the abutment sloped gently upward to a point, approximately the same elevation as the crest of the dam, some 100 feet from the embankment contact. The right abutment gently sloped upward away from the embankment. No seepage was observed in or around either abutment except for the above mentioned seepage. No evidence of slope movement or erosion was apparent in either abutment.

No rodent activity was observed in either the embankment or the abutments.

Downstream of the dam, good exposures of a massive sandstone were observed. This appears to be the Warrensburg-Moberly sandstone which is described as a thick channel sandstone and a part of the Pleasanton Group (Missourian Series, Pennsylvanian) (Geologic Map of Missouri, 1961). Some

erosion has exposed bedrock in the vicinity of the dam.

c. Appurtenant Structures

(1) Spillways

The gunite spillway (service spillway) and discharge channel appear to be, overall, in satisfactory condition, however, the remedial measures described in Section 7.2 should be undertaken as recommended. No evidence of structural cracking or spalling could be found. Minor temperature cracks were observed on the side walls of the channel. The discharge channel is being undercut at the downstream end of the channel which is causing the floor of the gunite channel to crack and break off. A metal trashrack has been provided on the spillway. The trashrack is 16 feet wide and 29 inches tall expanded metal which is hinged along the top support. The trashrack can be swung up by pulling up on the bottom.

According to Mr. Don Tuley, the City Engineer, the gunite lining was added in 1967. Flood waters from a rainstorm washed out a portion of a park road downstream of the dam. The damaged area was repaired by a compacted clay fill and riprap. The gunite lining was provided to help channelize any water which flows through the spillway.

The concrete conduits of the emergency spillway are in excellent condition. No evidence of structural cracking or spalling could be found. No misalignment of the joints of the pipe were observed. The upstream and downstream channels of the spillway were overgrown with heavy vegetation. The spillway was constructed in 1960.

(2) Outlet Works

According to Mr. John West, Water Superintendent for the City of Moberly, Missouri, both of the pumps were taken out of service in 1922. The electrically driven pump is the only one which is still operable and it was last operated in 1976. Plans are being made to make necessary repairs on both the pumps to make them operable and to keep them in operable condition so that they can be used as a possible supplemental water supply.

d. Reservoir Area

The water surface elevation was approximately 806 feet above MSL on the day of the inspection.

The reservoir rim is gently to moderately sloped and no indications of instability were readily apparent. The slopes above the reservoir are heavily wooded. No buildings or dwellings are built on or near the shoreline, with only a few boat docks on the shoreline. The property around the lake is part of Rothwell Park owned by the City of Moberly, Missouri.

e. Downstream Channel

The channel immediately downstream of the service spillway discharge channel is a well-defined, earth cut channel. The channel is irregular in shape and has side slopes which are nearly vertical. Bedrock was exposed in the channel.

The channel downstream of the emergency spillway is a well-defined, earth cut channel. The outlet of the emergency spillway is overgrown with heavy vegetation. The channel has some vegetation and no riprap protection.

The two channels converge downstream of the dam and then pass through a 60-inch C.M.P. culvert which passes under an asphalt park road. No major obstacles or debris were observed along the channel downstream from the culvert.

3.2 Evaluation

The seepage area located 36 feet upstream of the downstream end on the right side of the service spillway channel is serious enough to need immediate remedial action.

The following problems were observed which could affect the safety of the dam or which will require maintenance within a reasonable period of time.

1. The service spillway channel is being undercut at the downstream end.

2. The intake and discharge ends of the emergency spillway are overgrown by heavy vegetation.

3. Erosion of the upstream crest and slope by wave action and storm runoff.

4. The vegetation and several trees growing on the upstream slope and the one large tree growing on the downstream slope.

SECTION 4: OPERATIONAL PROCEDURES

4.1 Procedures

Water Works Lake Dam is used to impound water for recreational use and has no particular procedure for operation at this time. The water level is controlled by rainfall, runoff, evaporation, seepage and the spillway crest elevation. Future plans are to make the two pumps in the pumphouse downstream of the dam operable for use as a possible supplemental water supply for the city.

4.2 Maintenance of Dam

Water Works Lake Dam is maintained by the Moberly City Parks and Recreation Department. The maintenance section is under the direction of Mr. Oran Patrick, who was present on the day of the inspection. The dam appears to be adequately maintained. Nevertheless, the vegetation and several trees on the upstream slope and the one large tree on the downstream slope should be removed and an adequate grass cover retained on both the upstream and the downstream slopes of the dam. The seepage observed 36 feet upstream of the downstream end of the service spillway channel should be investigated and repaired as required.

In 1967, the service spillway channel was lined with gunite and in 1960, the emergency spillway structure was constructed. City crews are presently dumping random fill on the downstream slope to flatten it.

4.3 Maintenance of Operating Facilities

At this time, the only operating facilities at the dam are the two pumps, one diesel powered and the other electrically driven, located in the pumphouse downstream of the dam. The pumps were originally used to pump water from the Water Works Reservoir into the city water supply system, but were taken out of service in 1922. The electrically driven pump is the only pump which is in working condition and was last tested in 1976 by the Water Superintendant. Future plans are being made to make necessary repairs on both the pumps to make them operable.

4.4 Description of Any Warning System in Effect

The inspection team was not informed of any warning system in effect for Water Works Lake Dam.

4.5 Evaluation

The maintenance of the dam appears to be adequate. Nevertheless, the remedial measures described in Section 7 should be undertaken within the time specified.

SECTION 5: HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design

The watershed area of the Water Works Lake Dam upstream from the dam axis consists of approximately 418 acres. About 50 percent of the watershed area is wooded and the rest of the area is agricultural land. Land gradients in the watershed average roughly 2 percent. The Water Works Lake Reservoir is located on an unnamed tributary of Sweet Spring Creek. The reservoir is about 400 feet upstream from the confluence of the unnamed tributary and Sweet Spring Creek. At its longest arm the watershed is approximately 0.6 mile long. A drainage map showing the watershed area is presented as Plate 1 in Appendix B.

Evaluation of the hydraulic and the hydrologic features of Water Works Lake Dam was based on criteria set forth in the Corps of Engineers' "Recommended Guidelines for Safety Inspection of Dams", and additional guidance provided by the St. Louis District of the Corps of Engineers. The Probable Maximum Flood (PMF) was calculated from the Probable Maximum Precipitation (PMP) using the methods outlined in the U.S. Weather Bureau Publication, Hydrometeorological Report No. 33. The probable maximum storm duration was set at 24 hours, and storm rainfall distribution was based on criteria given in EM 1110-2-1411 (Standard Project Storm). The SCS method was used for deriving the unit hydrograph, utilizing the Corps of Engineers' computer program HEC-1 (Dam Safety

Version). The unit hydrograph parameters are presented in Appendix B. The SCS method was also used for determining the loss rate. The hydrologic soil group of the watershed was determined by use of published soil maps. The hydrologic soil group of the watershed and the SCS curve number are also presented in Appendix B. The curve number, the unit hydrograph parameters, the PMP index rainfall and the percentages for various durations were directly input to the HEC-1 (Dam Safety Version) computer program to obtain the PMF hydrograph. The computed peak discharges of the PMF and one-half of the PMF are 7,205 cfs and 3,603 cfs respectively.

Both the PMF and one-half of the PMF inflow hydrographs were routed through the reservoir by the Modified Puls Method also utilizing the HEC-1 (Dam Safety Version) computer program. The reservoir was assumed at the spillway crest level at the start of the routing computation. The peak outflow discharges for the PMF and one-half of the PMF are 5,182 and 2,197 cfs respectively. Both the PMF and one-half of the PMF, when routed through the reservoir result in overtopping of the dam.

The stage-outflow relation for the spillway was prepared from field notes and sketches, prepared during the field inspection. The reservoir stage-capacity data were based on the U.S.G.S. Moberly, Missouri Quandrangle topographic map (7.5 minute series). The spillway and overtop rating curve and the reservoir capacity curve are presented in Plates 2 & 3 respectively in Appendix B.

From the standpoint of dam safety, the hydrologic design of a dam aims at avoiding overtopping. Overtopping is especially dangerous for an earth dam because the downrush of waters over the crest can erode the dam embankment and release

all the stored water suddenly into the downstream floodplain. The safe hydrologic design of a dam requires a spillway discharge capability, in combination with an embankment crest height that can handle a very large and exceedingly rare flood without overtopping.

The Corps of Engineers designs its dams to safely pass the Probable Maximum Flood that is estimated could be generated from the upstream watershed. This is the generally accepted criterion for major dams throughout the world, and is the standard for dam safety where overtopping would pose any threat to human life. According to the Corps' criteria, the hydrologic requirement for safety for this dam is the capability to pass from one-half of the Probable Maximum Flood to the Probable Maximum Flood without overtopping.

b. Experience Data

No records of reservoir stage or spillway discharge are maintained for this site. However, according to the owner's representative, the maximum reservoir level was above the crest of an old spillway by several feet and damaged the park road below the dam. The spillway was reconstructed after this event. The dam has never been overtopped.

c. Visual Observations

Observations made of the spillway during the visual inspection are discussed in Section 3.1c(1) and evaluated in Section 3.2.

d. Overtopping Potential

As indicated in Section 5.1a, both the Probable Maximum Flood and one-half of the Probable Maximum Flood, when routed through the reservoir, resulted in overtopping of the dam. The peak outflow discharges for the PMF and one-half of the PMF are 5,182 cfs and 2,197 cfs respectively. The PMF overtopped the dam crest by 4.28 feet and one-half of the PMF overtopped the dam crest by 2.53 feet. The total duration of embankment overflow is 12.75 hours during the PMF, and 7.58 hours during one-half of the PMF. The maximum capacity for the spillway without any freeboard is about 135 cfs. The spillway for Water Works Lake Dam is capable of passing a flood equal to approximately 9 percent of the PMF just before overtopping the dam. The 100-year flood is equal to approximately 12 percent of the PMF. The spillway/reservoir system will not accommodate the 100-year flood without overtopping the dam. However, the spillway and the reservoir will accommodate the 10-year flood without overtopping. The 10-year flood is approximately equal to 7 percent of the Probable Maximum Flood.

The failure of the dam could cause extensive damage to the property downstream of the dam and possible loss of life. The estimated damage zone extends about one and one-half miles downstream of the dam. Within the damage zone are eight dwellings, one pumphouse, a sewage disposal plant and several improved road crossings.

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

There were no signs of settlement or distress observed on the embankment or foundation during the visual inspection except for the erosion of the upstream slope above the water surface due to storm runoff and wave action. The damage due to the storm runoff and wave action is not serious at this time, however, the areas should be repaired and the slope protected from further damage within a reasonable period of time. The heavy vegetative growth and several trees on the upstream slope and the one large tree on the downstream slope present a potential hazard to the structural stability of the embankment.

The seepage located 36 feet upstream of the downstream end of the service spillway channel indicates a possible danger to the structural stability of the dam. The seepage should be investigated immediately and repairs made as required.

The random fill being placed on the downstream slope to flatten it is adding to the structural stability of the dam, even though the material being used is of a lesser quality than what is generally used for embankment material.

Both the service and the emergency spillways appear to be structurally stable. The minor cracking observed in the side slopes of the service spillway appears to be temperature cracks and does not pose a danger to the stability of the structure. The undercutting of the spillway channel at the downstream end does not affect the safety of the spillway in its present condition, however, the undercutting should be repaired.

It is not known if the dam is founded on bedrock. If the dam is founded on bedrock, the central part of the dam would most likely be founded on the Warrensburg-Moberly sandstone which would form a competent foundation. The abutments, if on bedrock, would possibly be resting on the thin-bedded sandstone of the Pleasanton Group. For a small dam, these beds appear to be satisfactory for a foundation.

b. Design and Construction Data

No design computations were uncovered during the report preparation phase. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available. No embankment or foundation soil parameters are available for carrying out a conventional stability analysis on the embankment. No construction data or specifications relating to the degree of embankment compaction are available for use in a stability analysis.

c. Operating Records

No operating records are available relating to the stability of the dam. The water level on the day of the inspection was at the crest of the service spillway, and it is assumed that the reservoir remains close to full at all times.

d. Post Construction Changes

The construction of the gunite lining on the service spillway in 1967 provides structural stability to the dam. The lining helps channelize any water or future flood waters which may pass through the spillway away from the downstream embankment.

The emergency spillway which was constructed in 1960 increases the hydraulic capacity of the dam to pass a flood. Nevertheless, because the invert of the spillway is at a higher elevation than the crest of the dam near the left abutment, the spillway does not help the structural stability of the dam.

No other post construction changes will affect the structural stability of the dam.

e. Seismic Stability

The dam is located in Seismic Zone 1, as defined in "Recommended Guidelines for Safety Inspection of Dams" as prepared by the Corps of Engineers, and therefore, does not require a seismic stability analysis.

SECTION 7: ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

It should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team.

It is also important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there by any chance that an unsafe condition could be detected.

a. Safety

The spillway capacity of Water Works Lake Dam was found to be "Seriously Inadequate". The spillway/reservoir system will accommodate only 9 percent of the PMF without overtopping the dam.

The erosion due to wave action on the upstream embankment slope, if allowed to continue, could jeopardize the safety of the dam. Therefore, the erosion should be repaired and the slope protected from further damage. The vegetation and the trees on the upstream slope and the one large tree on the downstream slope should be removed from the slopes and an adequate protective grass cover retained on the slopes. This should be accomplished under the guidance of an engineer experienced in the design and construction of earthen dams. Indiscriminate clearing could jeopardize the safety of the embankment. No signs of distress were observed in the embankment or in the foundation.

The seepage located 36 feet upstream of the downstream end of the spillway channel could pose a potential danger to the safety of the embankment. It is recommended that a seepage and stability analyses be performed to determine the source of the seepage and the effect of the seepage on the stability of the embankment. No seepage and stability analyses were available for review.

The heavy vegetation around the intake and outlet of the emergency spillway will obstruct the normal functioning of the spillway. However, at the present time the emergency spillway is higher than the lowest point on the dam crest. The undercutting of the downstream end of the service spillway does not affect the safety of the dam in its present condition, however, it should be repaired and protected from further damage.

b. Adequacy of Information

The conclusions presented in this report are based on field measurements, the available engineering data, past performance and present condition of the dam. Information on the design hydrology, hydraulic design, and the operation and maintenance of the dam as well as seepage and stability analyses were not available. To supplement available data and allow for a more definite evaluation of the dam, it is recommended that the following programs be initiated:

1. Periodic inspection of the dam by an engineer experienced in the design and construction of earthen dams should be made and this inspection report made a matter of record.

2. Set up a maintenance schedule and log all visits to the dam for operation, repairs and maintenance.

3. Perform seepage and stability analyses comparable to the "Recommended Guidelines for Safety Inspection of Dams".

c. Urgency

The remedial measures recommended in Paragraph 7.2 should be accomplished within a reasonable period of time. The items recommended in paragraph 7.2a should be pursued on a high priority basis.

d. Necessity for Phase II Inspection

Based on results of the Phase I inspection, and if the remedial measures recommended in Paragraph 7.2 are undertaken as specified, a Phase II inspection is not felt to be necessary.

7.2 Remedial Measures

a. Alternatives:

1. Spillway capacity and/or height of the dam should be increased to accommodate the PMF without overtopping the dam. The overtopping depth during the occurrence of the PMF, stated elsewhere in this report, is not the required or recommended increase in height of the dam.

2. The seepage located 36 feet upstream of the downstream end of the service spillway channel should be investigated. Seepage and stability analyses should be performed by a professional engineer experienced in the design and construction of earthen dams.

b. O & M Procedures:

1. Repair the undercutting of the downstream end of the service spillway channel.

2. Remove the vegetation around the intake and outlet of the emergency spillway.

3. Repair the erosion of the upstream crest and slope due to wave action and storm runoff.

4. Remove the vegetation and several trees from the upstream slope and the one large tree on the downstream slope and retain an adequate protective grass cover on both slopes. Removal of trees should be performed under the direction of an engineer experienced in the design and construction of earth dams.

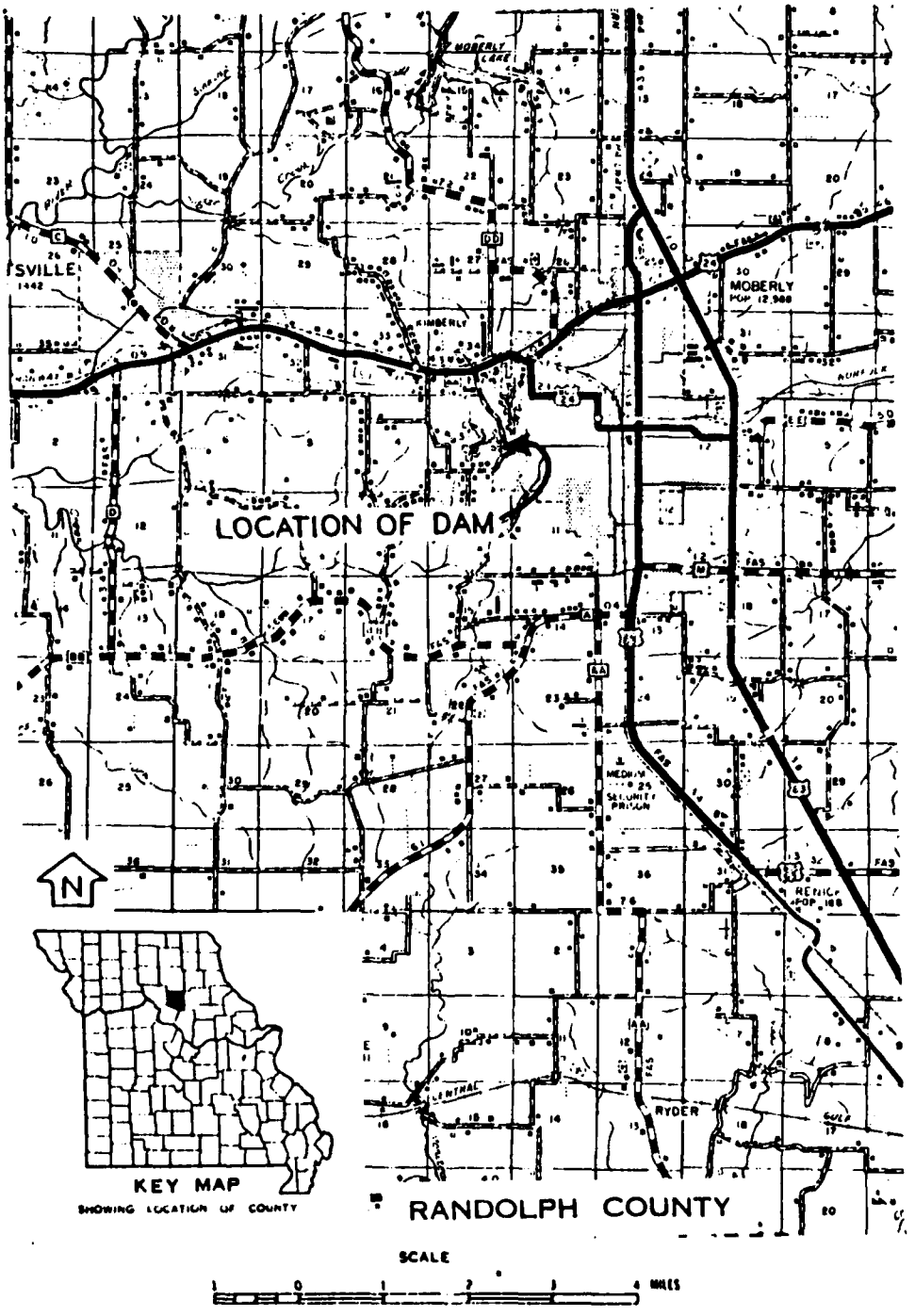
5. The owner should initiate the following programs:

   a. Periodic inspection of the dam by a professional engineer experienced in the design and construction of earthen dams.

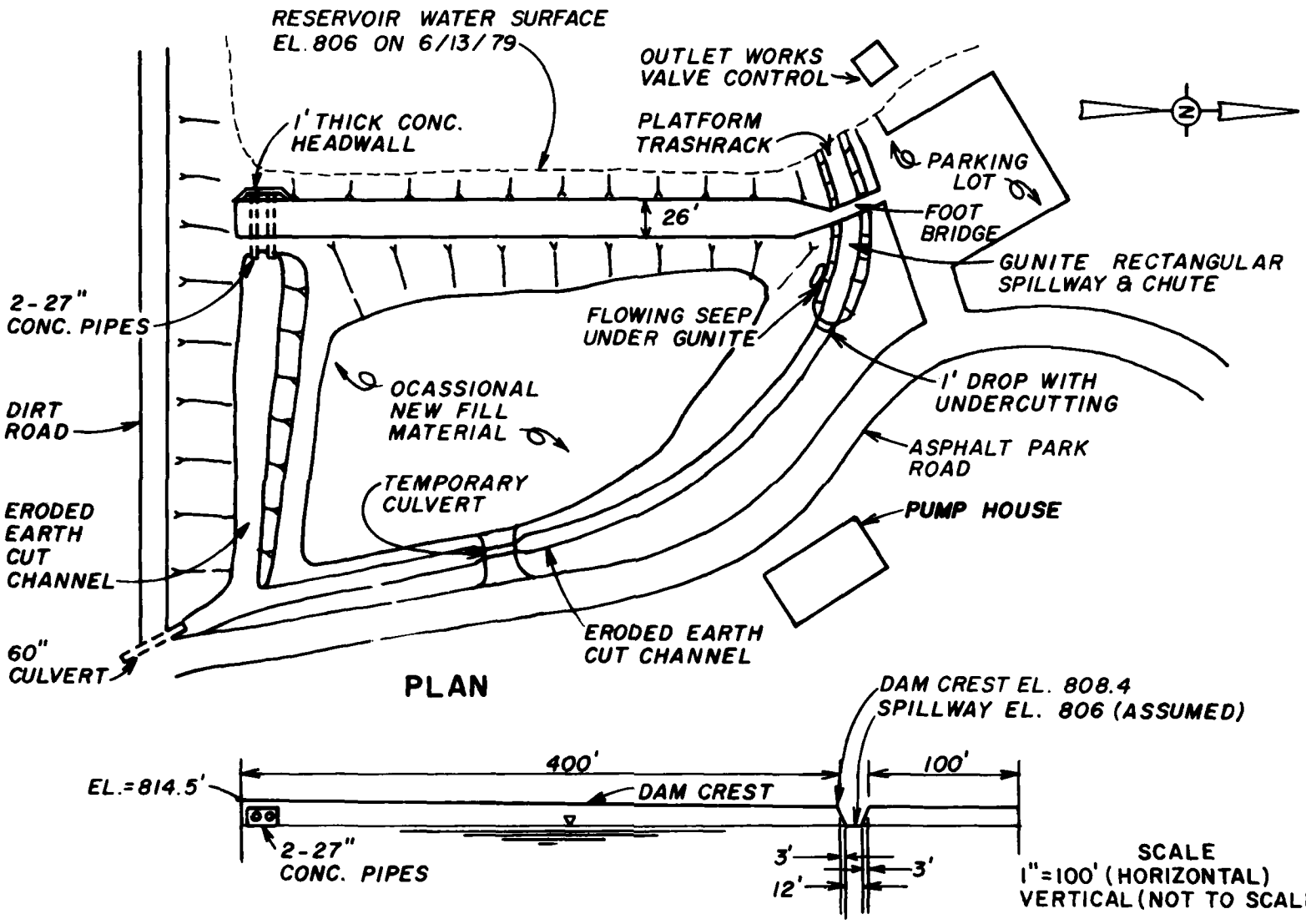
   b. Set up a maintenance schedule and log all visits to the dam for operation, repairs and maintenance.

PLATES

PLATE I



LOCATION MAP - WATER WORKS LAKE DAM



WATER WORKS LAKE DAM (MO. 10006)
PLAN & ELEVATION

P-3

PLATE 2

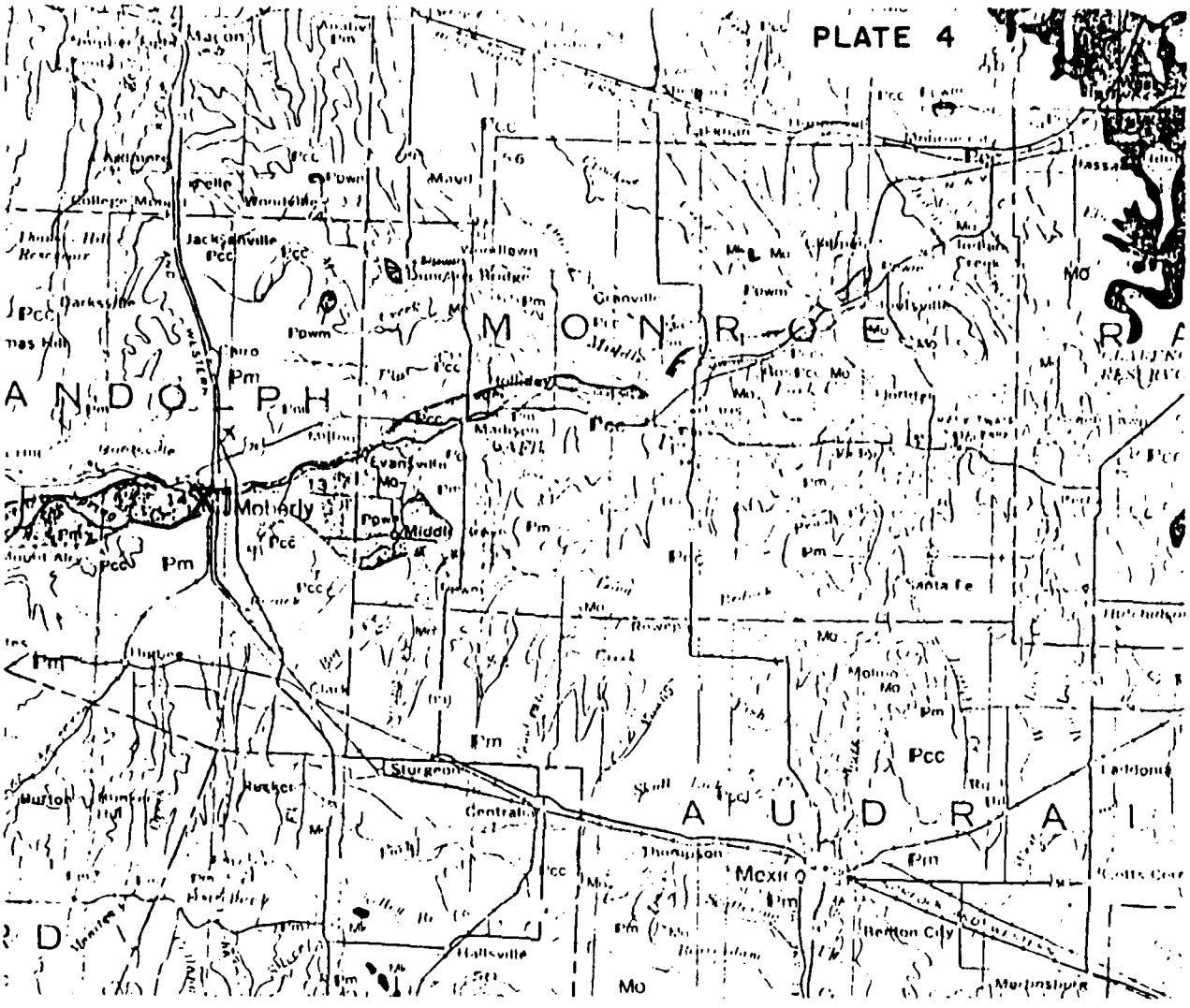
PLATE 3

TYPICAL SECTION OF EMBANKMENT

Water Works Lake Dam (Mo 10006)

TYPICAL SECTION OF EMBANKMENT

PLATE 4



PENNSYLVANIAN

- Rp - PLEASANTON GROUP
- Rpwm - WARRENSBURG - MOBERLY SANDSTONE
- Rm - MARMATON GROUP
- Rcc - CHEROKEE GROUP

MISSISSIPPIAN

- Mm - MERAMACIAN SERIES
- Mo - OSAGIAN SERIES
- Mk - KINDERHOOKIAN SERIES

X - LOCATION OF DAM, MO. 10006

REFERENCE:

GEOLOGIC MAP OF MISSOURI,
MISSOURI GEOLOGIC SURVEY,
a) 1961 ; b) 1979

GEOLOGIC MAP
OF
MONROE COUNTY
AND
ADJACENT AREA

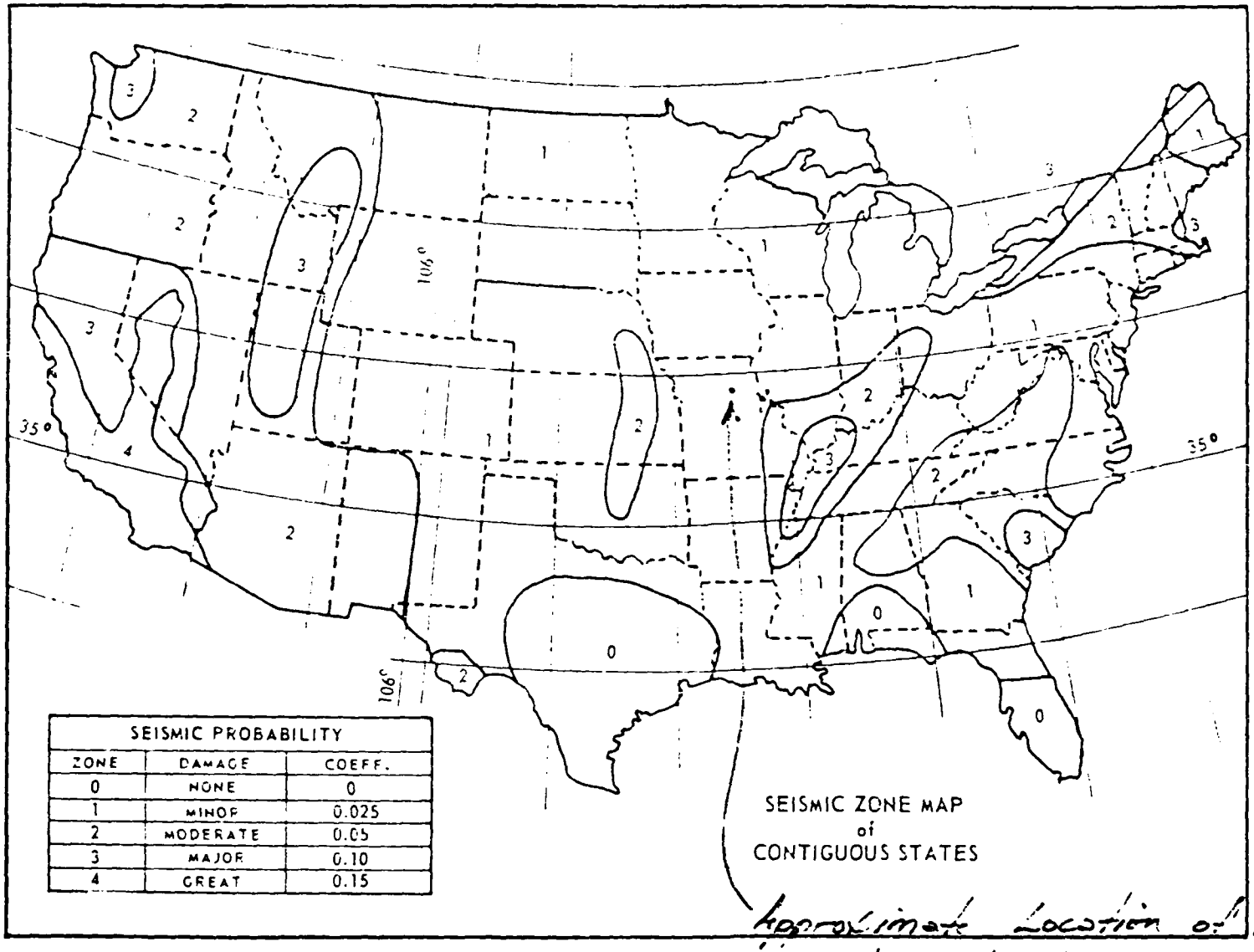

106°
35°
SEISMIC PROBABILITY
ZONE | DAMAGE | COEFF.
0 | NONE | 0
1 | MINOR | 0.025
2 | MODERATE | 0.05
3 | MAJOR | 0.10
4 | GREAT | 0.15
SEISMIC ZONE MAP
of
CONTIGUOUS STATES
Approximate Location of Water Works Lake Dam.

PLATE 5

APPENDIX A

PHOTOGRAPHS TAKEN DURING INSPECTION

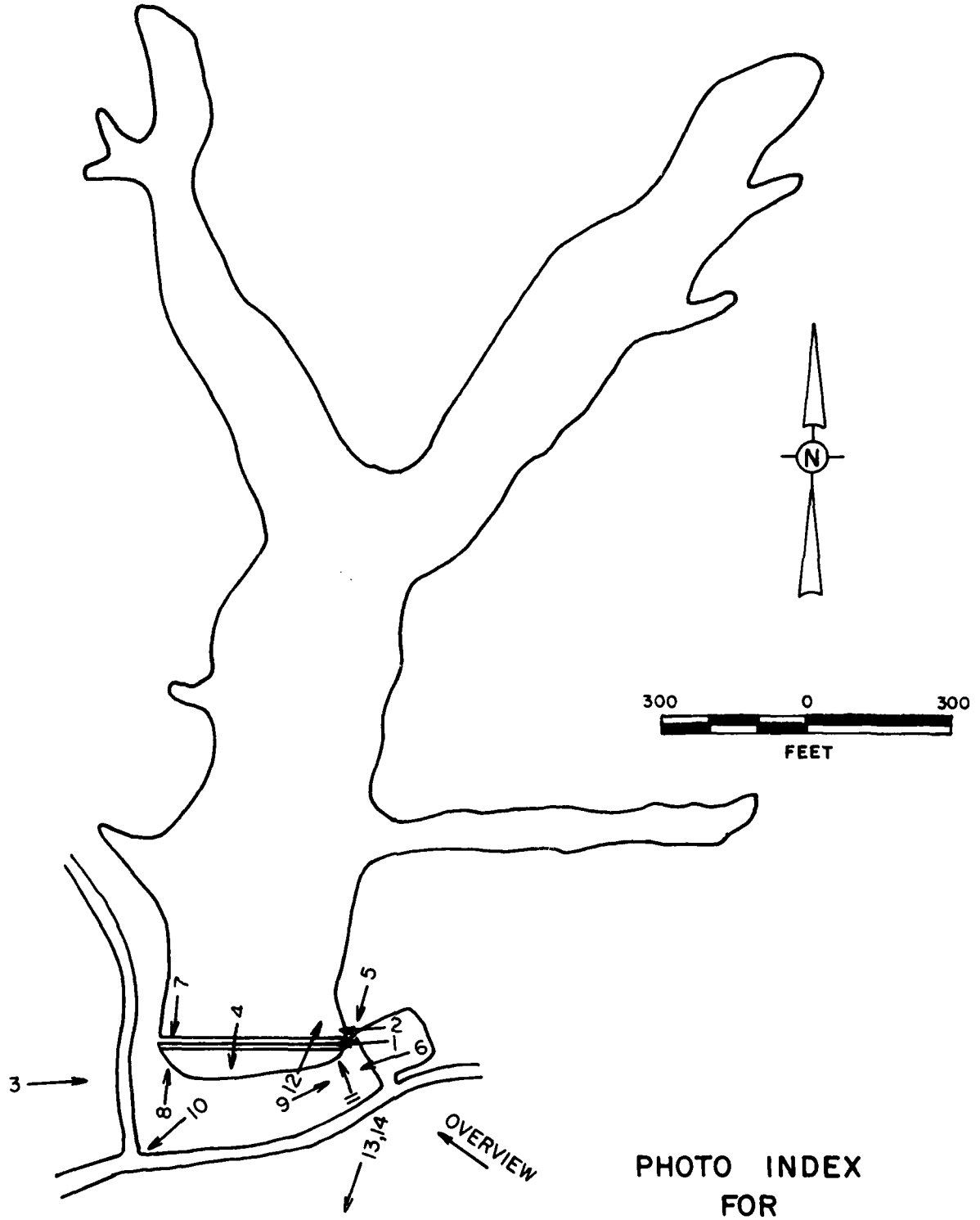


PHOTO INDEX
FOR
WATER WORKS LAKE DAM

Water Works Lake Dam

Photo 1. - View of the crest of the embankment.

Photo 2. - View of the upstream embankment slope.

Photo 3. - View of the downstream embankment slope.

Photo 4. - View of the random dumping of material on the downstream slope.

Photo 5. - View of the service spillway and trashrack.

Photo 6. - View of the service spillway discharge channel.

Photo 7. - View of the intake to emergency spillway.

Photo 8. - View of the outlet of the emergency spillway.

Photo 9. - View of the erosion at the downstream end of service spillway discharge channel.

Photo 10. - View of the downstream channel.

Photo 11. - View of the seepage on the left abutment near the downstream end of the service spillway discharge channel.

Photo 12. - View of the intake control structure.

Photo 13. - View of the diesel powered pump.

Photo 14. - View of the electric driven pump.

Photo 1

Photo 2

Photo 3

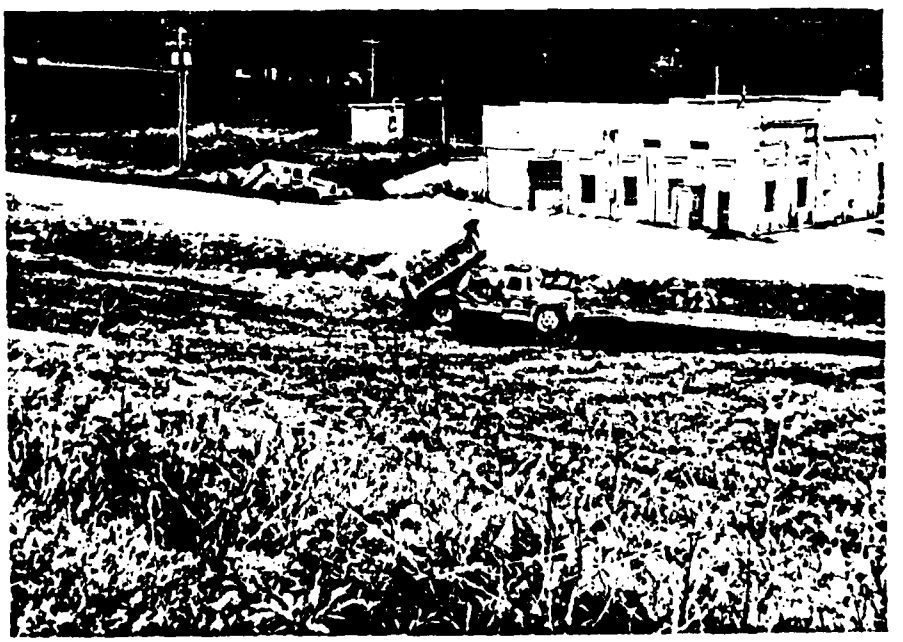


Photo 4

Water Works Lake Dam

Photo 5

Photo 6

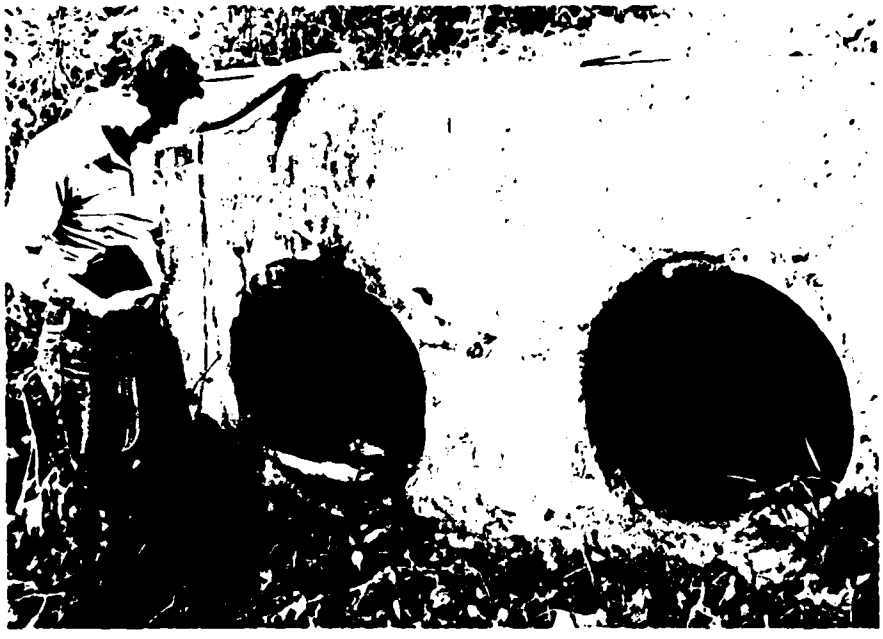


Photo 7

Photo 8

Water Works Lake Dam

Photo 9

Photo 10

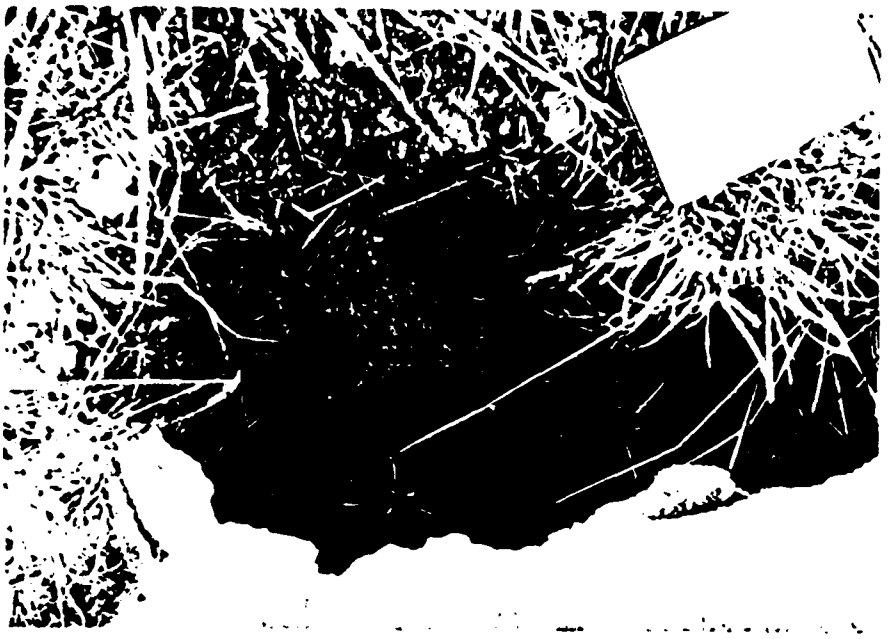


Photo 11

Photo 12

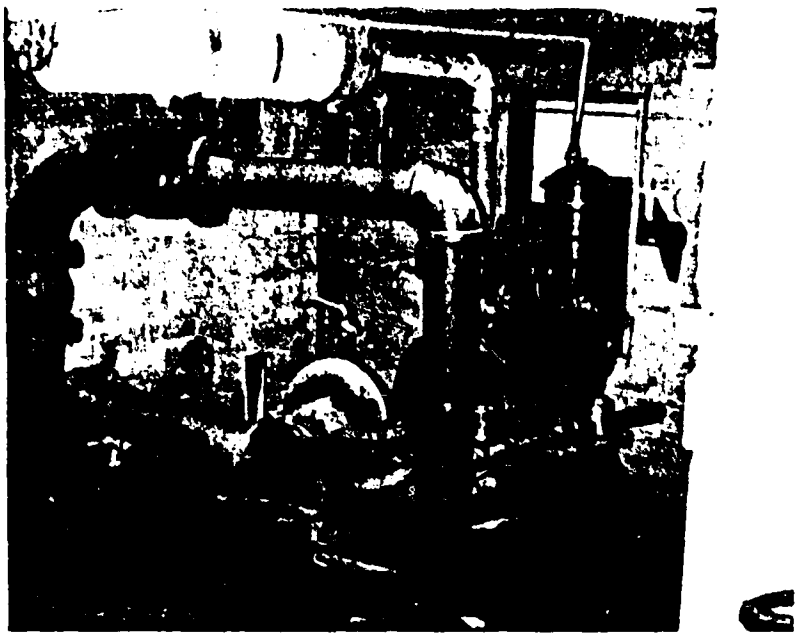


Photo 13

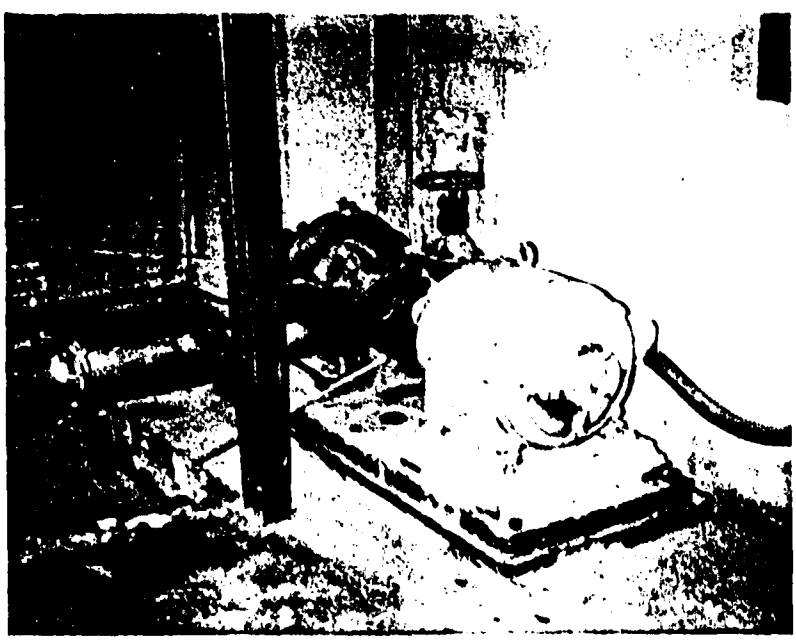
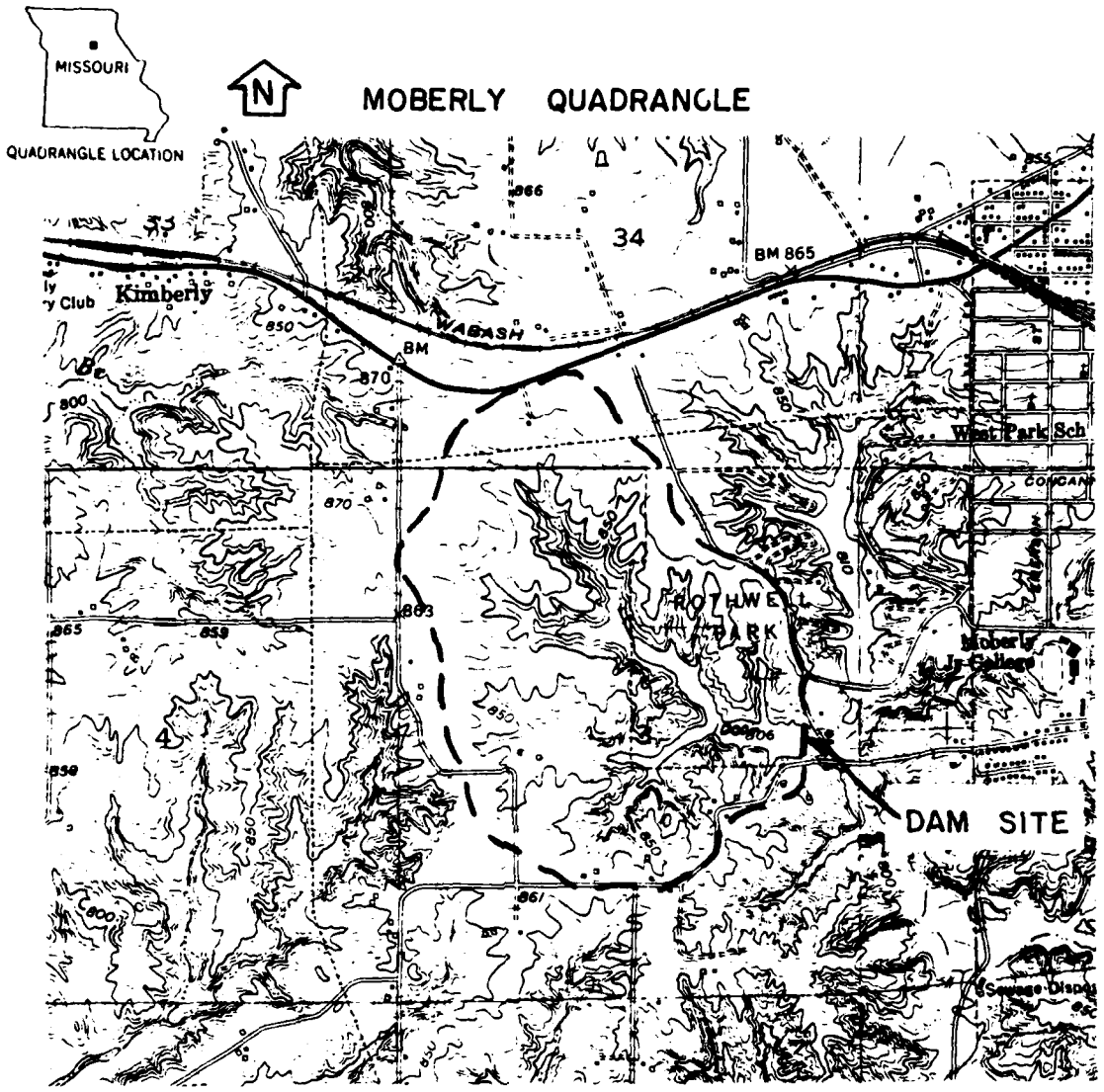


Photo 14

APPENDIX B

HYDROLOGIC COMPUTATIONS

PLATE I , APPENDIX B

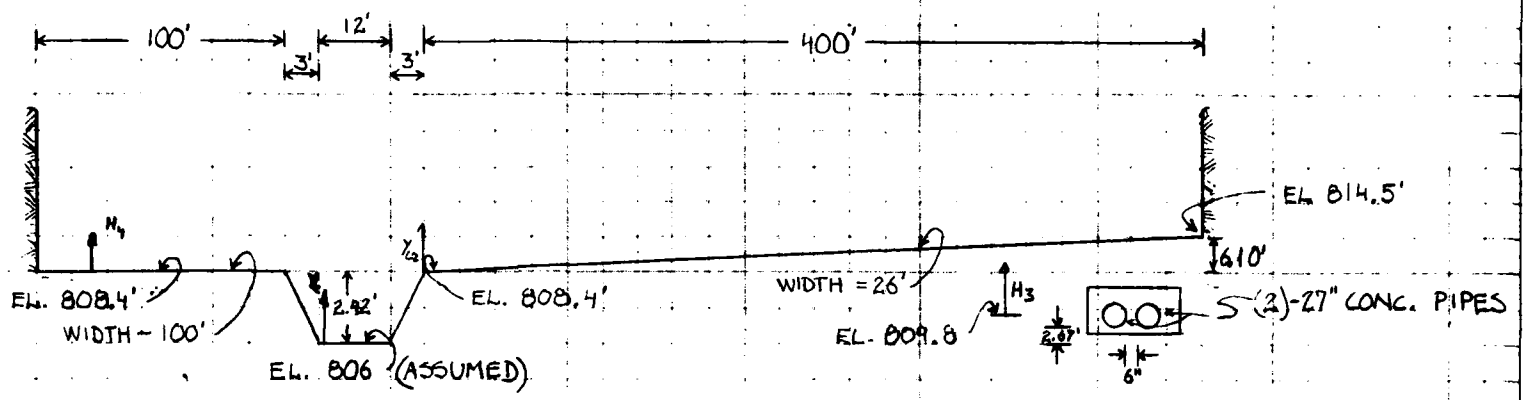


WATER WORKS LAKE DAM (MO 10006)
DRAINAGE BASIN

DAM SAFETY INSPECTION - MISSOURI SHEET NO. 1 OF

WATERWORKS LAKE DAM (MO # 10006) JOB NO. 1240

SPILLWAY & OVERTOP RATING CURVE BY DNZ DATE 6/27/79



Y_{c1}	A_{c1}	T_{c1}	$V_{c1}=5.67\sqrt{A_{c1}/T_{c1}}$	$V_{c1}^2/2g$	$Q_{c1}=A_{c1}V_{c1}$	U/S W.S. $=Y_{c1}+\frac{V_{c1}^2}{2g}+806$	$Q_3=4554\times Y H_{T_3}^{3/2}$ ABOVE EL. 811.8	Y_{c2}	A_{c2}	T_{c2}	V_{c2}	$Q_{c2}=A_{c2}V_{c2}$	C_4	L_4	H_4	$Q_4=C_4L_4H_4^{3/2}$	$Q_T=Q_1+Q_2+Q_3+Q_{c4}$
0	–	–	–	–	–	806	–	–	–								0
1	13.24	14.98	5.42	.46	72	807.46	–	–									72
2	28.96	16.76	7.41	.85	215	808.85	–	.30	2.95	19.67	2.20	6.0	2.70	100	.45	82	303
3	46.7	18	9.04	1.30	427	810.30	6	1.27	52.88	83.28	4.52	239	2.63	100	1.90	689	1361
4	64.7	18	10.75	1.80	696	811.80	64	2.27	169	149	6.03	1020	2.63	100	3.4	1649	3360
5	82.7	18	12.16	2.29	1005	813.29	85	3.26	348	214	7.24	2519	2.63	100	4.9	2853	6462
6	100.7	18	13.41	2.79	1351	814.79	102	4.26	595	279	8.28	4927	2.63	100	6.4	4258	10638

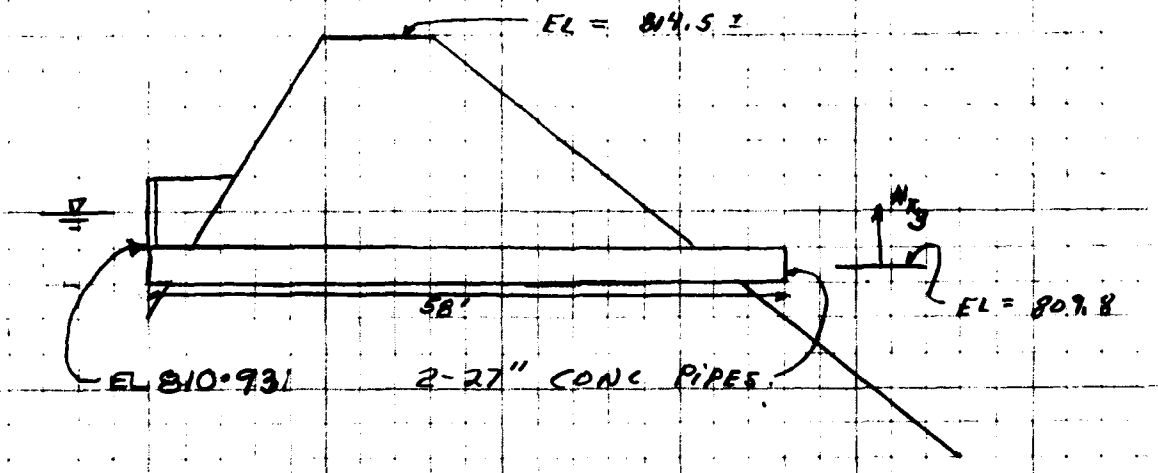
B-3

DAM SAFETY INSPECTION - missouri SHEET NO. 2 OF

WATERWORKS LAKE DAM(MO00006) JOB NO. 1240-001-1

SPILLWAY AND OVERTOP RATING CURVE BY KLB DATE 6-19-7

RIGHT SIDE EMERGENCY SPILLWAY.



ASSUME NO TAIL WATER EFFECTS

ASSUME PRESSURE FLOW CONTROLS
ABOVE W.L. AT. ELEV. = 811.8 (Refer to Sheet 1)

AT W.L. = 811.8 H_{F_3} = 811.8 - 809.8 = 2'

$$H_{F_3} = \left(1.0 + K_e + f\frac{L}{D}\right)\frac{V^2}{2g}$$

Assume $f = 0.018$, Complete turbulence.

& $K_e = 0.5$

$$H_{F_3} = \left(1.0 + 0.5 + 0.018\,\frac{58}{2.25}\right)\frac{V^2}{2g}$$

$$H_{F_3} = 1.96\,\frac{V^2}{2g}, \Rightarrow V = 5.73\sqrt{H_{F_3}}$$

$$Q = A \cdot V = \pi\frac{D^2}{4} \times 5.73\sqrt{H_{F_3}} = 22.77\sqrt{H_{F_3}} \text{ (ONE PIPE)}$$

AT W.L 811.8, BOTH PIPES FLOWING FULL

$$Q = 2 \times 22.77 \sqrt{H_{T_3}} = 45.54 \sqrt{H_{T_3}}$$

$$Q = 45.54 \times \sqrt{2} = 64 \text{ CFS.}$$

ASSUME THE EQUATION $Q = 45.54\sqrt{H_{T_3}}$ HOLDS FOR ALL RESERVOIR W.L ELEVATIONS ABOVE 811.8

Open Channel flow through pipes:

Say $Y_c \approx \frac{2}{3} E_o$ for flow through circular section.

At U.S. W.S. El = 808.85 (Ref Sh. 45) $E_o = 808.85 - 808.68 = 0.17'$

At U/S. W.S. El = 810.3, $E_o = 1.62$, $Y_c = 1.09'$

$\Rightarrow Y_c \simeq 0.17 \times \frac{2}{3} = 0.113'$

$Q_c \simeq 0$

$$\therefore Q_c = \frac{0.251(\theta - \sin\theta)^{1.5}}{(\sin \tfrac{1}{2}\theta)^{0.5}} d_0^{2.5}$$

for $Y_c = 1.09'$, $\theta = 2\sin^{-1}\frac{\sqrt{4Y_c(2R - Y_c)}}{2R}$

$$= 2\sin^{-1}\frac{\sqrt{4 \times 1.09'(4.5 - 1.09)}}{4.5}$$

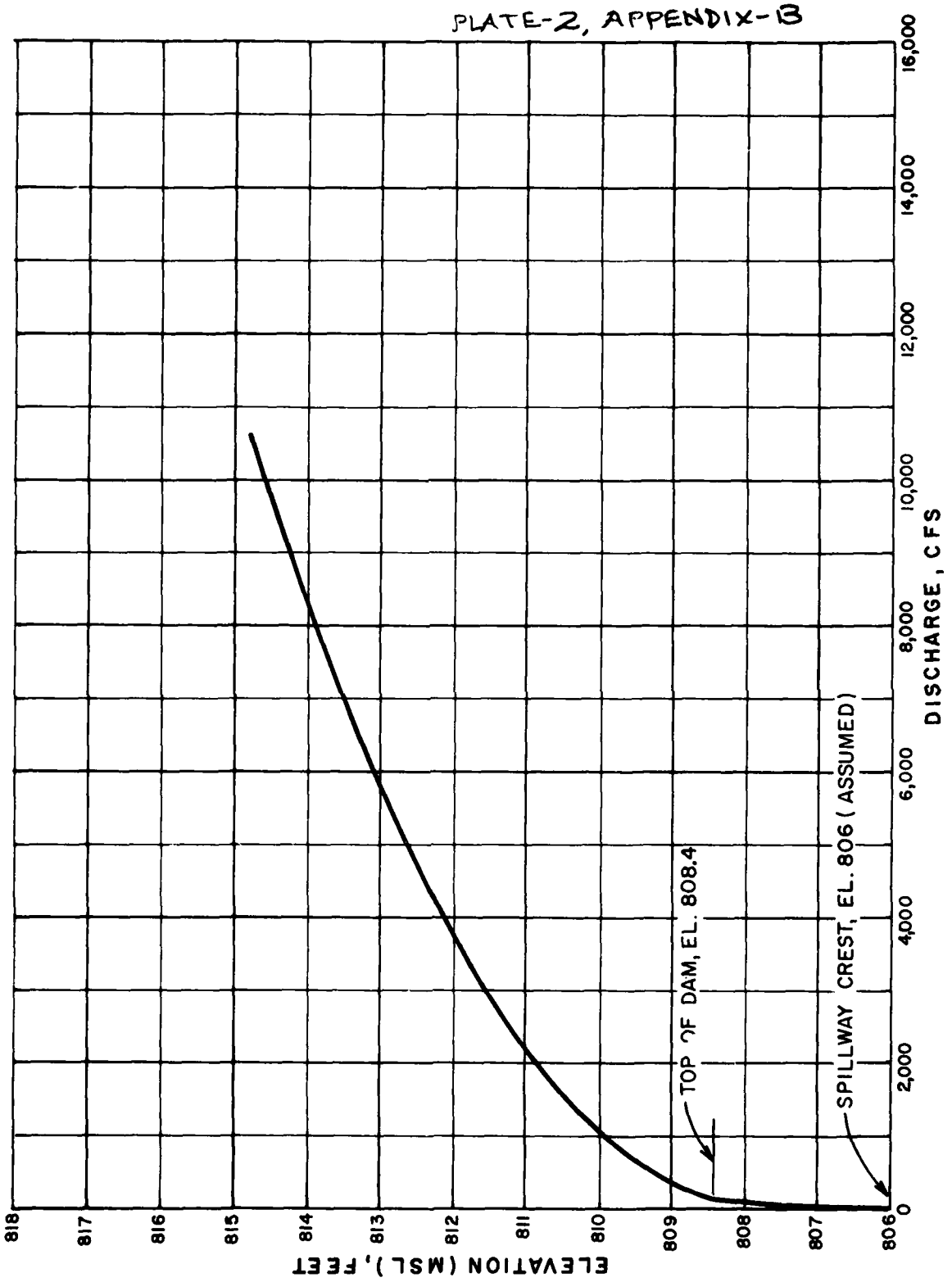
$$= 117.93^\circ = 2.06 \text{ radians}$$

$$\therefore Q_c = \frac{0.251(2.06 - \sin 117.93^\circ)^{1.5}}{(\sin 58.97^\circ)^{0.5}} (2.25)^{2.5}$$

$\simeq 3$ cfs.

$2Q_c = 6$ cfs

PLATE-2, APPENDIX-B



WATERWORKS LAKE DAM (MO. 10006)
SPILLWAY & OVERTOP RATING CURVE

ICI-4 ENGINEERING CONSULTANTS, INC.

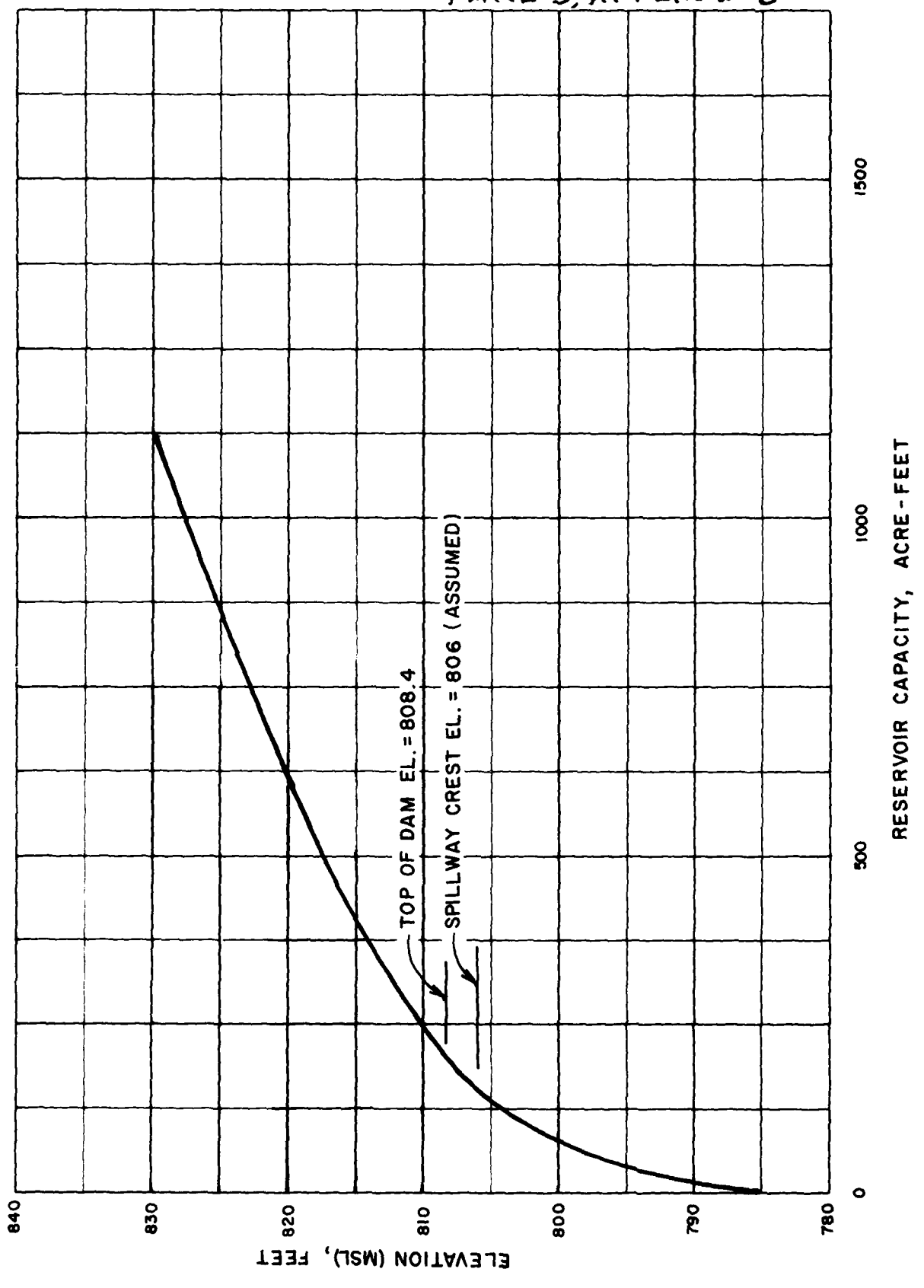
DAM SAFETY INSPECTION - MISSOURI SHEET NO. 1 OF
WATERWORKS LAKE DAM (MO.10006) JOB NO. 1240
RESERVOIR AREA CAPACITY BY DNZ M.R.H. DATE 31/5/79

WATER WORKS LAKE DAM

RESERVOIR AREA CAPACITY

ELEV. M S L (ft)	RESERVOIR SURFACE AREA (ACRES)	INCREMENTAL VOLUME (AC-Ft)	TOTAL VOLUME (AC-Ft)	REMARKS
785	0	0	0	EST. STREAMBED AT DAM
806	21	147	147	W.S. AS SHOWN ON U.S.G.S MAPS (Elev. Known)
808.4	24	54	201	TOP OF DAM ELEV.
820	47	404	605	
830	17	614	1219	

PLATE-3, APPENDIX-B



WATERWORKS LAKE DAM (MO. 10006)
RESERVOIR CAPACITY CURVE

WATER WORKS LAKE DAM (MO. #10006)

DETERMINATION OF PMP

1) DETERMINE DRAINAGE AREA OF BASIN

D. A. = 418 ACRES

2.) DETERMINE PMP INDEX RAINFALL (200 SQ. mi & 24 HR. DURATION)

LOCATION OF CENTROID OF BASIN.

LONG = 92°28' 18", LAT = 39°25' 13"

PMP = 24.4 IN. (FROM FIG. 1, HMR #33)

3.) DETERMINE BASIN RAINFALL IN TERMS OF PERCENTAGE OF PMP INDEX RAINFALL FOR VARIOUS DURATIONS.

LOCATION: LONG. = 92°28'18", LAT. = 39°25'18"

⇒ ZONE 7

DURATION (HRS)	PERCENT OF INDEX RAINFALL	TOTAL RAINFALL (IN)	RAINFALL INCREMENTS	DURATION OF INCREMENTS
6	100	24.4	24.4	6
12	120	29.3	4.9	6
24	130	31.7	2.4	12

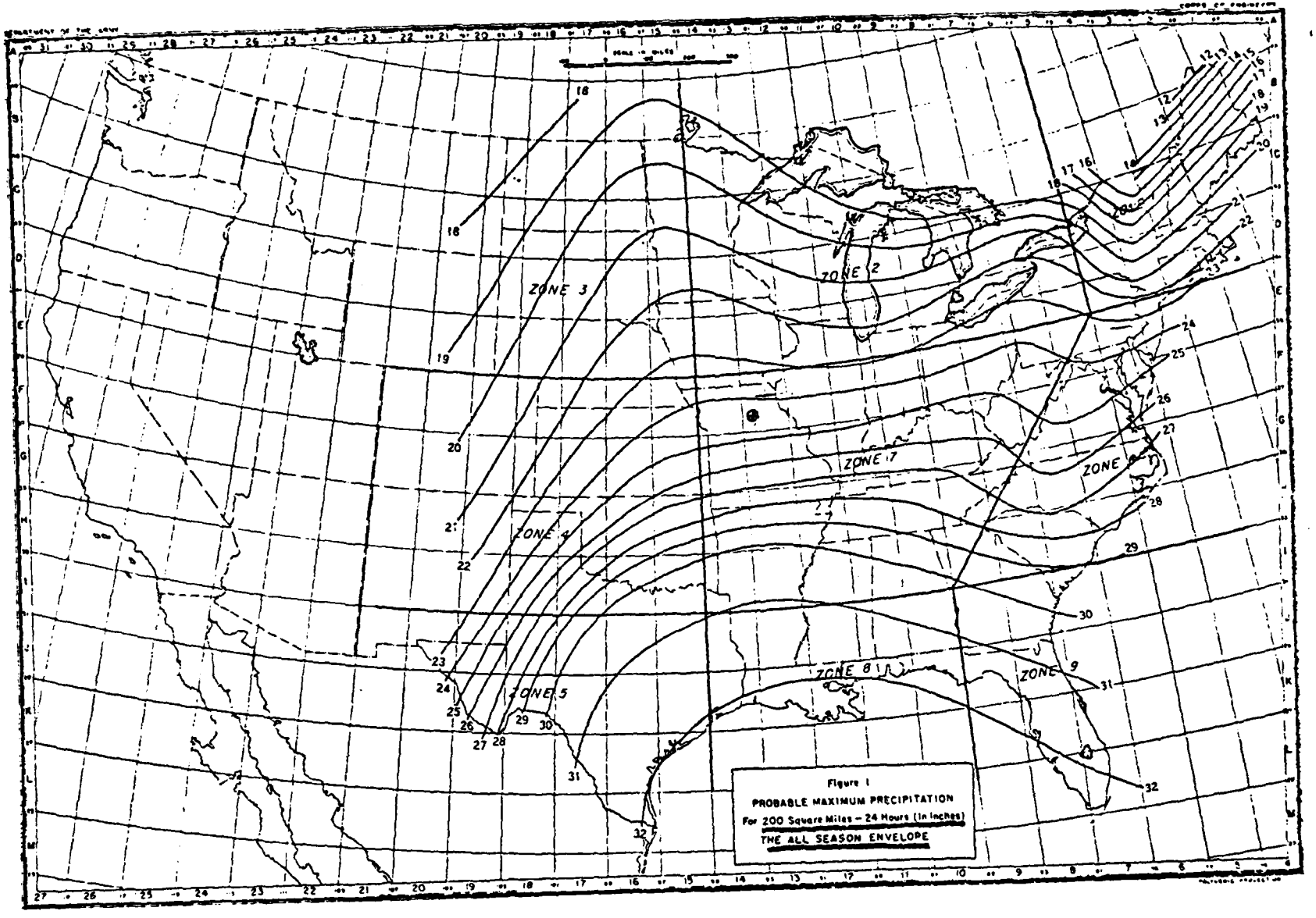


Figure 1
PROBABLE MAXIMUM PRECIPITATION
For 200 Square Miles – 24 Hours (In Inches)
THE ALL SEASON ENVELOPE

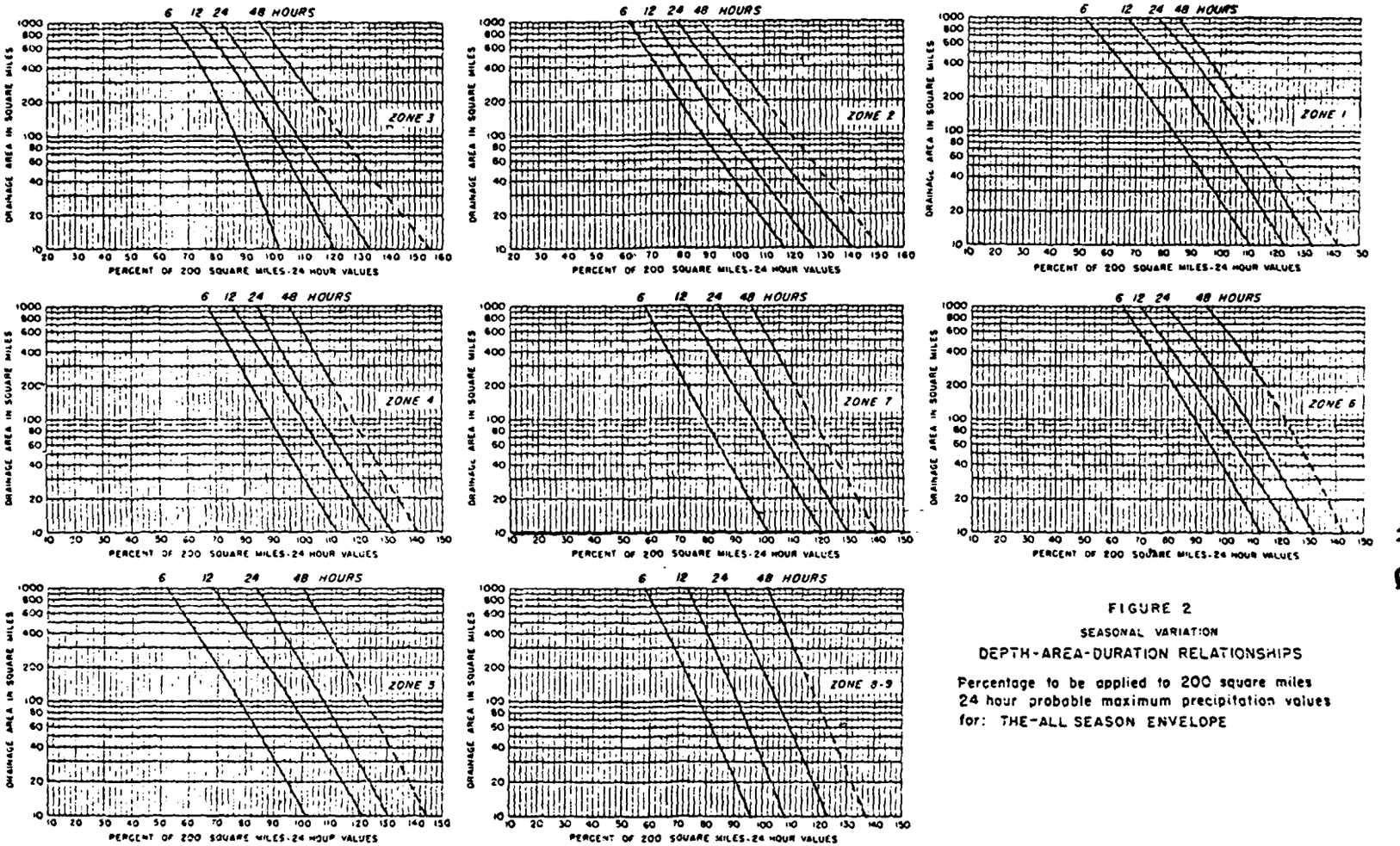


FIGURE 2

SEASONAL VARIATION

DEPTH-AREA-DURATION RELATIONSHIPS

Percentage to be applied to 200 square miles 24 hour probable maximum precipitation values for: THE-ALL SEASON ENVELOPE

ECI-4 ENGINEERING CONSULTANTS, INC.

DAM SAFETY INSPECTION - MISSOURI SHEET NO. 1 OF 1
WATERWORKS LAKE DAM (MO. 10006) JOB NO. 1240
UNIT HYDROGRAPH PARAMETERS BY DNZ DATE 6/11/79
CHKD

1. DRAINAGE AREA, A = 418 ACRES = 0.65 SQ. MI.
2. LENGTH OF STREAM, L_s = 3100 feet = 0.59 miles
3. ELEVATION AT DRAINAGE DIVIDE ALONG LONGEST STREAM
   H_1 = 872
4. RESERVOIR ELEVATION AT SPILLWAY CREST, H_2 = 806
5. DIFFERENCE IN ELEVATION, ΔH = 66
6. AVERAGE SLOPE OF STREAM = $\frac{\Delta H}{L} = \frac{66}{3100}$ = 2.13 %
7. TIME OF CONCENTRATION:
   a) BY KIRPICH FORMULA:
   $$T_c = \left(\frac{11.9 \times L^3}{\Delta H}\right)^{0.385} = \left(\frac{11.9 \times .59^3}{66}\right)^{.385} = 0.28 \text{ HRS}$$
   b) BY VELOCITY ESTIMATE: AVG VEL = 3 FPS
   $$T_c = \frac{L}{V} = \frac{2481}{3(60 \times 60)} = 0.23 \text{ HR}$$
   USE T_c = 0.28
8. LAG TIME, $L_t = 0.6 \times 0.28 = 0.17$
9. UNIT DURATION, $D \leq \frac{L_t}{3} = 0.056 < 0.083$
   USE D = 0.083
10. TIME TO PEAK, $T_p = \frac{D}{2} + L_t = \frac{0.083}{2} + 0.17 = 0.212$
11. PEAK DISCHARGE, $q_p = \frac{484 A}{T_p} = \frac{484(.65)}{0.212} = 1484$
    q_p = 1484 cfs.

WATER WORKS LAKE DAM (MO. 10006)

DETERMINATION OF HYDROLOGIC SOIL GROUP AND SCS CURVE NUMBER

1. Watershed Soils consist primarily of Group 'D' Soils. Assume Soil group 'D' for the whole watershed.

2. About 50 percent of the watershed is wooded. Assume rest of the area is farmed.

   Assume "Fair" condition for infiltration purpose.

   Thus $CN = \frac{79 \times 5 + 86 \times 5}{1} \approx 83$

   $\Rightarrow CN = 93$ for AMC III

WATERWORKS LAKE DAM

100 YR FLOOD BY REGRESSION EQUATION

REGRESSION EQUATION FOR THE 100 YR FLOOD FOR MISSOURI.

$$Q_{100} = 85.1\, A^{0.934\, A^{-0.02}}\, S^{0.576}$$

WHERE:

A = DRAINAGE AREA IN SQ. MI.

S = MAIN CHANNEL SLOPE FT/MI.
(AVG. SLOPE BETWEEN 0.1L AND 0.85L)

FOR WATERWORKS LAKE DAM:

A = 0.65 SQ. MI.

S = 113 FT/MI.

$$Q_{100} = 85.1\,(0.65)^{0.934\,(0.65)^{-0.02}}\,(113)^{0.576}$$

$$Q_{100} = 863 \text{ CFS}$$

WATERWORKS LAKE DAM

10 YEAR FLOOD BY REGRESSION EQUATION.

REGRESSION EQUATION FOR THE 10 YEAR FLOOD FOR MISSOURI:

$$Q_{10} = 67.6\, A^{0.905\, A^{-0.02}}\, S^{0.500}$$

WHERE:

A = DRAINAGE AREA IN SQ. MI.

S = MAIN CHANNEL SLOPE FT/MI.
(AVG. SLOPE BETWEEN 0.1 L AND 0.85 L).

FOR WATERWORKS LAKE DAM.

A = 0.65 SQ. MI.

S = 113 FT/MI.

$$Q_{10} = 67.6\, (0.65)^{0.905\, (0.65)^{-0.02}}\, (113)^{0.500}$$

Q_{10} = 485 cfs.

HEC1DB INPUT DATA

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
**********
    1                 A1                    DAM SAFETY INSPECTION - MISSOURI
    2                 A2                    WATERWORKS LAKE DAM (11006)
    3                 A3          PMF AND 50 PERCENT PMF DETERMINATION AND ROUTING
    4                 ID     300        0        5        3        3        0        0        0        0        0
    5                 IT      5
    6                 JD       1        2        1
    7                 JT     1.0      0.5
    8                 KK       0    10006                                                 1
    9                 K1 INPUT SMP INDEX RAINFALL AND RATIOS, INPUT SCS UNIT HYDROGRAPH PARAMETERS
   10                 J        1        2      0.65                0.65      1.0
   11                 P                24.4      100      120      130
   12                 T                                                              -1    -93.0
   13                 WP              0.17
   14                 X        0        0        1
   15                 KK       1    10206                                2                1
   16                 K1 ROUTE HYDROGRAPH THROUGH WATERWORKS LAKE DAM (10006)
   17                 Y                                        1        1
   18                 Y1       1                                                    -606.0          -1
   19                 Y2   805.0   807.45   808.40   808.55   810.50   811.40   813.29   814.79
   20                 Y5     0.0      72.     139.     303.    1261.    3360.    6462.   10639.
   21                 Y8     0.0     147.     281.     595.    1219.
   22                 Y7    78%.     906.    80e.4     720.     830.
   23                 Y4    605.
   24                 Y3   808.4
   25                 N       99
```

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

RUNOFF HYDROGRAPH AT	10006
ROUTE HYDROGRAPH TO	10006
END OF NETWORK	

INFLOW PMF AND ONE-HALF PMF HYDROGRAPHS

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
**********

RUN  DATE= 79/07/10.
     TIME= 09.44.28.
```

DAM SAFETY INSPECTION - MISSOURI
WATERWORKS LAKE DAM (10006)
PMF AND 50 PERCENT PMF DETERMINATION AND ROUTING

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
300	0	5	0	0	0	0	0	0	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 2 LRTIO= 1

RTIOS= 1.00 .50

********** *********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

INPUT PMP INDEX RAINFALL AND RATIOS, INPUT SCS UNIT HYDROGRAPH PARAMETERS

ISTA	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
10006	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUNG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	.65	0.00	.65	1.00	0.000	0	0	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
1.00	24.40	100.00	100.00	130.00	0.00	0.00	0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	-1.00	-99.00	0.00	0.00

CURVE NO = -99.00 WETNESS = -1.00 EFFECT CN = 99.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .17

RECESSION DATA
STRTQ= 0.00 QRCSN= 0.00 RTIOR= 1.00

UNIT HYDROGRAPH 12 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= .17 VOL= 1.00

451.	1365.	1402.	879.	441.	236.	125.	65.	35.	19.
10.	4.								

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	0.00	.01	0.	1.01	12.35	151	.20	.20	.00	994.
1.01	.10	2	.01	0.00	.01	0.	1.01	12.40	152	.20	.20	.00	1004.
1.01	.15	3	.01	0.00	.01	0.	1.01	12.45	153	.20	.20	.00	1009.
1.01	.20	4	.01	0.00	.01	0.	1.01	12.50	154	.20	.20	.00	1012.
1.01	.25	5	.01	0.00	.01	0.	1.01	12.55	155	.20	.20	.00	1014.
1.01	.30	6	.01	0.00	.01	0.	1.01	13.00	156	.20	.20	.00	1015.
1.01	.35	7	.01	0.00	.01	0.	1.01	13.05	157	.24	.24	.00	1033.
1.01	.40	8	.01	0.00	.01	0.	1.01	13.10	158	.24	.24	.00	1069.
1.01	.45	9	.01	0.00	.01	0.	1.01	13.15	159	.24	.24	.00	1146.
1.01	.50	10	.01	0.00	.01	0.	1.01	13.20	160	.24	.24	.00	1182.
1.01	.55	11	.01	0.00	.01	0.	1.01	13.25	161	.24	.24	.00	1200.
1.01	1.00	12	.01	.00	.01	0.	1.01	13.30	162	.24	.24	.00	1210.
1.01	1.05	13	.01	.00	.01	1.	1.01	13.35	163	.24	.24	.00	1215.
1.01	1.10	14	.01	.00	.01	0.	1.01	13.40	164	.24	.24	.00	1218.
1.01	1.15	15	.01	.00	.01	0.	1.01	13.45	165	.24	.24	.00	1220.
1.01	1.20	16	.01	.00	.01	0.	1.01	13.50	166	.24	.24	.00	1221.
1.01	1.25	17	.01	.00	.01	0.	1.01	13.55	167	.24	.24	.00	1222.
1.01	1.30	18	.01	.00	.01	0.	1.01	14.00	168	.24	.24	.00	1222.
1.01	1.35	19	.01	.00	.01	11.	1.01	14.05	169	.31	.31	.00	1259.
1.01	1.40	20	.01	.00	.01	13.	1.01	14.10	170	.31	.31	.00	1333.
1.01	1.45	21	.01	.00	.01	14.	1.01	14.15	171	.31	.31	.00	1410.
1.01	1.50	22	.01	.00	.01	15.	1.01	14.20	172	.31	.31	.00	1472.
1.01	1.55	23	.01	.00	.01	15.	1.01	14.25	173	.31	.31	.00	1499.
1.01	2.00	24	.01	.00	.01	15.	1.01	14.30	174	.31	.31	.00	1514.
1.01	2.05	25	.01	.00	.01	21.	1.01	14.35	175	.31	.31	.00	1521.
1.01	2.10	26	.01	.01	.01	23.	1.01	14.40	176	.31	.31	.00	1526.
1.01	2.15	27	.01	.01	.01	23.	1.01	14.45	177	.31	.31	.00	1529.
1.01	2.20	28	.01	.01	.01	25.	1.01	14.50	178	.31	.31	.00	1529.
1.01	2.25	29	.01	.01	.01	26.	1.01	14.55	179	.31	.31	.00	1530.
1.01	2.30	30	.01	.01	.01	27.	1.01	15.00	180	.31	.31	.00	1530.
1.01	2.35	31	.01	.01	.01	27.	1.01	15.05	181	.19	.19	.00	1477.
1.01	2.40	32	.01	.01	.01	27.	1.01	15.10	182	.37	.37	.00	1398.
1.01	2.45	33	.01	.01	.01	31.	1.01	15.15	183	.37	.37	.00	1463.
1.01	2.50	34	.01	.01	.01	31.	1.01	15.20	184	.56	.56	.00	1721.
1.01	2.55	35	.01	.01	.01	32.	1.01	15.25	185	.65	.65	.00	2126.
1.01	3.00	36	.01	.01	.01	33.	1.01	15.30	186	1.07	1.07	.00	2942.
1.01	3.05	37	.01	.01	.01	34.	1.01	15.35	187	2.60	2.60	.00	4026.
1.01	3.10	38	.01	.01	.01	35.	1.01	15.40	188	1.02	1.02	.00	7185.
1.01	3.15	39	.01	.01	.01	36.	1.01	15.45	189	.65	.65	.00	7265.
1.01	3.20	40	.01	.01	.01	37.	1.01	15.50	190	.56	.56	.00	5404.
1.01	3.25	41	.01	.01	.01	37.	1.01	15.55	191	.37	.37	.00	4366.
1.01	3.30	42	.01	.01	.01	38.	1.01	16.00	192	.37	.37	.00	3352.
1.01	3.35	43	.01	.01	.01	38.	1.01	16.05	193	.28	.28	.00	2632.
1.01	3.40	44	.01	.01	.01	39.	1.01	16.10	194	.28	.28	.00	2129.
1.01	3.45	45	.01	.01	.01	40.	1.01	16.15	195	.28	.28	.00	1811.
1.01	3.50	46	.01	.01	.01	41.	1.01	16.20	196	.28	.28	.00	1629.
1.01	3.55	47	.01	.01	.01	41.	1.01	16.25	197	.28	.28	.00	1535.
1.01	4.00	48	.01	.01	.00	42.	1.01	16.30	198	.28	.28	.00	1490.
1.01	4.05	49	.01	.01	.00	43.	1.01	16.35	199	.28	.28	.00	1461.
1.01	4.10	50	.01	.01	.00	43.	1.01	16.40	200	.28	.28	.00	1448.
1.01	4.15	51	.01	.01	.00	44.	1.01	16.45	201	.28	.28	.00	1435.
1.01	4.20	52	.01	.01	.00	44.	1.01	16.50	202	.28	.28	.00	1432.
1.01	4.25	53	.01	.01	.00	45.	1.01	16.55	203	.28	.28	.00	1431.
1.01	4.30	54	.01	.01	.00	45.	1.01	17.00	204	.28	.28	.00	1421.
1.01	4.35	55	.01	.01	.00	45.	1.01	17.05	205	.22	.22	.00	1404.
1.01	4.40	56	.01	.01	.00	46.	1.01	17.10	206	.22	.22	.00	1320.

1.01	4.45	57	.01	.01	.00	47.	1.01	17.1	207	.02	.02	.00	1235.
1.01	4.50	58	.01	.01	.00	47.	1.01	17.20	208	.02	.02	.00	1181.
1.01	4.55	59	.01	.01	.00	47.	1.01	17.25	209	.02	.02	.00	1159.
1.01	5.00	60	.01	.01	.00	48.	1.01	17.30	210	.02	.02	.00	1140.
1.01	5.05	61	.01	.01	.00	48.	1.01	17.35	211	.02	.02	.00	1133.
1.01	5.10	62	.01	.01	.00	49.	1.01	17.40	212	.02	.02	.00	1129.
1.01	5.15	63	.01	.01	.00	49.	1.01	17.45	213	.02	.02	.00	1127.
1.01	5.20	64	.01	.01	.00	49.	1.01	17.50	214	.02	.02	.00	1125.
1.01	5.25	65	.01	.01	.00	50.	1.01	17.55	215	.02	.02	.00	1125.
1.01	5.30	66	.01	.01	.00	50.	1.01	18.00	216	.02	.02	.00	1125.
1.01	5.35	67	.01	.01	.00	50.	1.01	18.05	217	.02	.02	.00	1033.
1.01	5.40	68	.01	.01	.00	51.	1.01	18.10	218	.02	.02	.00	756.
1.01	5.45	69	.01	.01	.00	51.	1.01	18.15	219	.02	.02	.00	471.
1.01	5.50	70	.01	.01	.00	51.	1.01	18.20	220	.02	.02	.00	292.
1.01	5.55	71	.01	.01	.00	52.	1.01	18.25	221	.02	.02	.00	202.
1.01	6.00	72	.01	.01	.00	52.	1.01	18.30	222	.02	.02	.00	155.
1.01	6.05	73	.05	.05	.01	71.	1.01	18.35	223	.02	.02	.00	129.
1.01	6.10	74	.07	.05	.01	190.	1.01	18.40	224	.02	.02	.00	116.
1.01	6.15	75	.07	.06	.01	192.	1.01	18.45	225	.02	.02	.00	109.
1.01	6.20	76	.07	.06	.01	235.	1.01	18.50	226	.02	.02	.00	105.
1.01	6.25	77	.07	.06	.01	256.	1.01	18.55	227	.02	.02	.00	103.
1.01	6.30	78	.07	.06	.01	270.	1.01	19.00	228	.02	.02	.00	102.
1.01	6.35	79	.07	.06	.01	279.	1.01	19.05	229	.02	.02	.00	102.
1.01	6.40	80	.07	.06	.01	286.	1.01	19.10	230	.02	.02	.00	102.
1.01	6.45	81	.07	.06	.01	291.	1.01	19.15	231	.02	.02	.00	102.
1.01	6.50	82	.07	.06	.01	295.	1.01	19.20	232	.02	.02	.00	102.
1.01	6.55	83	.07	.06	.01	298.	1.01	19.25	233	.02	.02	.00	102.
1.01	7.00	84	.07	.06	.01	301.	1.01	19.30	234	.02	.02	.00	102.
1.01	7.05	85	.07	.06	.01	303.	1.01	19.35	235	.02	.02	.00	102.
1.01	7.10	86	.07	.06	.01	305.	1.01	19.40	236	.02	.02	.00	102.
1.01	7.15	87	.07	.06	.01	307.	1.01	19.45	237	.02	.02	.00	102.
1.01	7.20	88	.07	.06	.01	309.	1.01	19.50	238	.02	.02	.00	102.
1.01	7.25	89	.07	.06	.01	311.	1.01	19.55	239	.02	.02	.00	102.
1.01	7.30	90	.07	.06	.01	312.	1.01	20.00	240	.02	.02	.00	102.
1.01	7.35	91	.07	.06	.00	314.	1.01	20.05	241	.02	.02	.00	102.
1.01	7.40	92	.07	.06	.00	315.	1.01	20.10	242	.02	.02	.00	102.
1.01	7.45	93	.07	.06	.00	316.	1.01	20.15	243	.02	.02	.00	102.
1.01	7.50	94	.07	.06	.00	318.	1.01	20.20	244	.02	.02	.00	102.
1.01	7.55	95	.07	.06	.00	319.	1.01	20.25	245	.02	.02	.00	102.
1.01	8.00	96	.07	.06	.00	320.	1.01	20.30	246	.02	.02	.00	102.
1.01	8.05	97	.07	.06	.00	321.	1.01	20.35	247	.02	.02	.00	102.
1.01	8.10	98	.07	.06	.00	321.	1.01	20.40	248	.02	.02	.00	102.
1.01	8.15	99	.07	.06	.00	322.	1.01	20.45	249	.02	.02	.00	102.
1.01	8.20	100	.07	.06	.00	323.	1.01	20.50	250	.02	.02	.00	102.
1.01	8.25	101	.07	.06	.00	324.	1.01	20.55	251	.02	.02	.00	102.
1.01	8.30	102	.07	.06	.00	324.	1.01	21.00	252	.02	.02	.00	102.
1.01	8.35	103	.07	.06	.00	325.	1.01	21.05	253	.02	.02	.00	102.
1.01	8.40	104	.07	.06	.00	325.	1.01	21.10	254	.02	.02	.00	102.
1.01	8.45	105	.07	.07	.00	326.	1.01	21.15	255	.02	.02	.00	102.
1.01	8.50	106	.07	.07	.00	327.	1.01	21.20	256	.02	.02	.00	102.
1.01	8.55	107	.07	.07	.00	327.	1.01	21.25	257	.02	.02	.00	102.
1.01	9.00	108	.07	.07	.00	328.	1.01	21.30	258	.02	.02	.00	102.
1.01	9.05	109	.07	.07	.00	328.	1.01	21.35	259	.02	.02	.00	102.
1.01	9.10	110	.07	.07	.00	329.	1.01	21.40	260	.02	.02	.00	102.
1.01	9.15	111	.07	.07	.00	329.	1.01	21.45	261	.02	.02	.00	102.
1.01	9.20	112	.07	.07	.00	329.	1.01	21.50	262	.02	.02	.00	102.
1.01	9.25	113	.07	.07	.00	330.	1.01	21.55	263	.02	.02	.00	102.
1.01	9.30	114	.07	.07	.00	330.	1.01	22.00	264	.02	.02	.00	102.
1.01	9.35	115	.07	.07	.00	331.	1.01	22.05	265	.02	.02	.00	102.
1.01	9.40	116	.07	.07	.00	331.	1.01	22.10	266	.02	.02	.00	102.

1.01	9.45	117	.07	.07	.00	331.	1.01	22.15	267	.02	.02	.00	102.
1.01	9.50	118	.07	.07	.00	331.	1.01	22.20	268	.02	.02	.00	102.
1.01	9.55	119	.07	.07	.00	332.	1.01	22.25	269	.02	.02	.00	102.
1.01	10.00	120	.07	.07	.00	332.	1.01	22.30	270	.02	.02	.00	102.
1.01	10.05	121	.07	.07	.0	332.	1.01	22.35	271	.02	.02	.00	102.
1.01	10.10	122	.07	.07	.00	333.	1.01	22.40	272	.02	.02	.00	102.
1.01	10.15	123	.07	.07	.00	333.	1.01	22.45	273	.02	.02	.00	102.
1.01	10.20	124	.07	.07	.00	333.	1.01	22.50	274	.02	.02	.00	102.
1.01	10.25	125	.07	.07	.00	333.	1.01	22.55	275	.02	.02	.00	102.
1.01	10.30	126	.07	.07	.00	333.	1.01	23.00	276	.02	.02	.00	102.
1.01	10.35	127	.07	.07	.00	334.	1.01	23.05	277	.02	.02	.00	102.
1.01	10.40	128	.07	.07	.00	334.	1.01	23.10	278	.02	.02	.00	102.
1.01	10.45	129	.07	.07	.00	334.	1.01	23.15	279	.02	.02	.00	102.
1.01	10.50	130	.07	.07	.00	334.	1.01	23.20	280	.02	.02	.00	102.
1.01	10.55	131	.07	.07	.00	334.	1.01	23.25	281	.02	.02	.00	102.
1.01	11.00	132	.07	.07	.00	334.	1.01	23.30	282	.02	.02	.00	102.
1.01	11.05	133	.07	.07	.00	335.	1.01	23.35	283	.02	.02	.00	102.
1.01	11.10	134	.07	.07	.00	335.	1.01	23.40	284	.02	.02	.00	102.
1.01	11.15	135	.07	.07	.00	335.	1.01	23.45	285	.02	.02	.00	102.
1.01	11.20	136	.07	.07	.00	335.	1.01	23.50	286	.02	.02	.00	102.
1.01	11.25	137	.07	.07	.00	335.	1.01	23.55	287	.02	.02	.00	102.
1.01	11.30	138	.07	.07	.00	335.	1.02	0.00	288	.02	.02	.00	102.
1.01	11.35	139	.07	.07	.00	335.	1.02	.05	289	0.00	0.00	0.00	93.
1.01	11.40	140	.07	.07	.00	336.	1.02	.10	290	0.00	0.00	0.00	65.
1.01	11.45	141	.07	.07	.00	336.	1.02	.15	291	0.00	0.00	0.00	37.
1.01	11.50	142	.07	.07	.00	336.	1.02	.20	292	0.00	0.00	0.00	19.
1.01	11.55	143	.07	.07	.00	336.	1.02	.25	293	0.00	0.00	0.00	10.
1.01	12.00	144	.07	.07	.00	336.	1.02	.30	294	0.00	0.00	0.00	5.
1.01	12.05	145	.20	.20	.00	336.	1.02	.35	295	0.00	0.00	0.00	3.
1.01	12.10	146	.20	.20	.0	573.	1.02	.40	296	0.00	0.00	0.00	1.
1.01	12.15	147	.20	.20	.0	767.	1.02	.45	297	0.00	0.00	0.00	1.
1.01	12.20	148	.20	.20	.00	865.	1.02	.50	298	0.00	0.00	0.00	0.
1.01	12.25	149	.20	.20	.00	945.	1.02	.55	299	0.00	0.00	0.00	0.
1.01	12.30	150	.20	.20	.00	977.	1.02	1.00	300	0.00	0.00	0.00	0.

SUM	31.70	30.83	.89	156114.
	(805.)(783.)(22.)(4302.34)			

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	7205.	1.85.	539.	517.	156127.
CMS	204.	4[illegible].	15.	15.	4[illegible].
INCHES		24.1[illegible]	30.83	30.83	30.83
MM		612.52	783.19	783.19	783.19
AC-FT		836.	1068.	1068.	1068.
THOUS CU M		1031.	1318.	1318.	1318.

HYDROGRAPH AT STA 10004 FOR PLAN 1, RTIO 1

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	1.	2.	3.	5.	7.	9.	11.	13.
14.	16.	18.	19.	21.	22.	23.	25.	26.	27.
28.	29.	30.	31.	32.	33.	34.	35.	36.	37.
37.	38.	39.	39.	40.	41.	41.	42.	43.	43.
44.	44.	45.	45.	46.	46.	47.	47.	47.	48.
48.	49.	49.	49.	50.	50.	50.	51.	51.	51.
52.	52.	71.	100.	192.	233.	256.	270.	279.	291.
291.	295.	298.	301.	303.	305.	307.	309.	311.	312.
314.	315.	316.	317.	319.	320.	321.	321.	322.	323.
324.	324.	325.	326.	326.	327.	327.	328.	328.	329.

329.	329.	330.	330.	331.	331.	331.	331.	332.	332.
332.	333.	333.	333.	333.	333.	334.	334.	334.	334.
334.	334.	335.	335.	335.	335.	335.	335.	335.	336.
336.	336.	336.	336.	396.	579.	767.	885.	945.	977.
994.	1004.	1009.	1012.	1014.	1015.	1035.	1089.	1146.	1182.
1207.	1214.	1215.	1218.	1220.	1221.	1222.	1222.	1250.	1333.
1414.	1472.	1499.	1514.	1521.	1526.	1528.	1529.	1530.	1530.
1477.	1598.	1683.	1721.	2125.	2982.	5026.	7189.	7205.	5804.
4596.	3363.	2653.	2129.	1813.	1629.	1529.	1486.	1451.	1440.
1439.	1432.	1431.	1431.	1434.	1320.	1214.	1161.	1155.	1140.
1135.	1129.	1127.	1125.	1125.	1125.	1054.	956.	471.	292.
202.	156.	134.	116.	109.	105.	103.	102.	102.	102.
102.	102.	102.	102.	102.	102.	102.	102.	102.	102.
102.	102.	102.	102.	102.	102.	102.	102.	102.	102.
102.	102.	102.	102.	102.	102.	102.	102.	102.	102.
102.	102.	102.	102.	102.	102.	102.	102.	102.	102.
102.	102.	102.	102.	102.	102.	102.	102.	102.	102.
102.	102.	102.	102.	102.	102.	102.	102.	93.	65.
37.	19.	10.	5.	3.	1.	1.	0.	0.	0.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	7205.	1685.	539.	517.	155107.
CMS	204.	48.	15.	15.	4393.
INCHES		24.12	7.72	20.43	6.18
MM		612.52	783.19	747.19	783.19
AC-FT		836.	1070.	1026.	1070.
THOUS CU M		1031.	1319.	1266.	1319.

HYDROGRAPH AT STA 1001 FOR PLAN 1, RTIO 2

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	1.	2.	3.	4.	5.	6.	6.
7.	8.	9.	10.	10.	11.	12.	12.	13.	14.
14.	15.	17.	16.	16.	17.	17.	17.	18.	18.
19.	19.	19.	20.	20.	20.	21.	21.	21.	22.
22.	23.	22.	23.	23.	24.	23.	23.	24.	24.
24.	24.	24.	25.	25.	25.	25.	25.	26.	26.
26.	26.	36.	65.	94.	116.	129.	135.	140.	143.
145.	147.	149.	150.	152.	153.	154.	155.	155.	156.
157.	158.	159.	159.	159.	160.	160.	161.	161.	162.
162.	162.	163.	163.	163.	163.	164.	164.	164.	164.
165.	165.	165.	165.	165.	165.	165.	166.	166.	166.
166.	166.	166.	166.	167.	167.	167.	167.	167.	167.
167.	167.	167.	167.	167.	168.	168.	168.	168.	168.
168.	168.	168.	168.	178.	290.	388.	443.	472.	489.
497.	502.	504.	506.	507.	507.	517.	544.	573.	591.
600.	605.	608.	609.	610.	610.	611.	611.	625.	666.
709.	736.	748.	757.	761.	763.	764.	765.	765.	765.
738.	699.	741.	860.	1063.	1451.	2513.	3592.	5603.	2902.
2192.	1676.	1316.	1165.	905.	815.	768.	740.	726.	720.
717.	716.	716.	716.	702.	660.	617.	591.	577.	570.
566.	564.	563.	561.	560.	560.	517.	378.	235.	146.
101.	77.	65.	58.	54.	53.	52.	51.	51.	51.
51.	51.	51.	51.	51.	51.	51.	51.	51.	51.
51.	51.	51.	51.	51.	51.	51.	51.	51.	51.
51.	51.	51.	51.	51.	51.	51.	51.	51.	51.
51.	51.	51.	51.	51.	51.	51.	51.	51.	51.
51.	51.	51.	51.	51.	51.	51.	51.	51.	51.
91.	51.	51.	51.	51.	51.	51.	51.	47.	33.

18.	9.	5.	3.	1.	1.	0.	0.	0.	0.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	3603.	843.	269.	259.	77564.
CMS	102.	24.	8.	7.	2196.
INCHES		12.06	15.42	15.42	15.42
MM		306.76	391.60	391.60	391.60
AC-FT		418.	534.	534.	534.
THOUS CU M		515.	659.	659.	659.

....

HYDROGRAPH ROUTING

ROUTE HYDROGRAPH THROUGH WATERWORKS LAKE DAM (10006)

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
10006	1	0	0	2	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-806.	-1

STAGE	806.00	807.45	808.46	808.88	810.30	811.80	813.29	814.79
FLOW	0.00	72.00	136.00	303.00	1361.00	3360.00	6462.00	10635.00

CAPACITY=	0.	147.	201.	605.	1219.
ELEVATION=	785.	806.	808.	820.	830.

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
806.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
808.4	0.0	0.0	0.

STATION 10006, PLAN 1, RATIO 1

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
1.	1.	1.	2.	2.	2.	2.	3.	3.	3.
4.	4.	5.	5.	5.	6.	6.	7.	7.	7.
8.	8.	9.	9.	10.	10.	11.	11.	12.	12.
13.	13.	13.	14.	14.	15.	15.	16.	16.	17.
17.	18.	18.	19.	19.	20.	20.	20.	21.	21.
22.	22.	23.	24.	26.	29.	32.	36.	39.	43.
46.	50.	54.	58.	61.	65.	68.	72.	77.	82.
86.	91.	96.	100.	104.	109.	113.	117.	121.	12[illegible].
130.	134.	143.	156.	168.	180.	190.	200.	209.	21[illegible].

PERCENT OF PMF FLOOD ROUTING
EQUAL TO SPILLWAY CAPACITY

****
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 26 FEB 79
****

RUN DATE= 79/07/10.
TIME= 09.44.18.

DAM SAFETY INSPECTION - MISSOURI
WATERWORKS LAKE DAM (10006)
PERCENT OF PMF DETERMINATION AND ROUTING

JOB SPECIFICATION

NO	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
300	0	5	0	0	0	3	0	4	0
			JOPER	NMT	LROPT	TRACE			
			1	0	0	0			

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 9 LRTIO= 1

RTIOS= .05 .06 .07 .08 .09 .10 .11 .12 .13

****

SUB-AREA RUNOFF COMPUTATION

INPUT PMP INDEX RAINFALL AND RATIOS, INPUT SCS UNIT HYDROGRAPH PARAMETERS

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
10006	0	0	0	0	0	1	3	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TAREA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	.65	0.00	.65	1.00	0.000	0	0	1

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	24.90	100.00	120.00	130.00	0.00	0.00	0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	-1.00	-93.00	0.00	0.00

CURVE NO = -93.00 WETNESS = -1.00 EFFECT CN = 93.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .17

RECESSION DATA
STRTQ= 0.00 QRCSN= 0.00 RTIOR= 1.00

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q

SUM 31.72 30.83 .89 155114.
(806.)(783.)(22.)(4392.34)

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HYDROGRAPH ROUTING

ROUTE HYDROGRAPH THROUGH WATERWORKS LAKE DAM (1S006)

ISTAG	ICOMP	IECON	ITAPE	JPLT	JPRT	ISAME	ISTAGE	IAUTO
17306	1	1	1	1	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	ICON	IPMP	LSTR
0.0	0.00	0.00	1	1	0	0	0

NSTPS	STOL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-6636.	-1

STAGE	806.00	807.00	813.40	814.00	818.50	811.80	813.20	819.79
FLOW	0.00	72.00	139.00	393.00	1561.00	3360.00	6402.00	10638.00
CAPACITY=	0.	147.	201.	495.	1319.			
ELEVATION=	785.	805.	808.	820.	830.			

CREL	SPIL	COQ	EXPL	ELEVL	COQL	EXPL	EXPL
805.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWT
809.0	0.0	0.0	0.

PEAK OUTFLOW IS 62. AT TIME 17.25 HOURS

PEAK OUTFLOW IS 75. AT TIME 17.25 HOURS

PEAK OUTFLOW IS 91. AT TIME 17.17 HOURS

PEAK OUTFLOW IS 106. AT TIME 17.17 HOURS

PEAK OUTFLOW IS 121. AT TIME 17.17 HOURS

PEAK OUTFLOW IS 141. AT TIME 17.08 HOURS

PEAK OUTFLOW IS 183. AT TIME 16.33 HOURS

PEAK OUTFLOW IS 226. AT TIME 16.25 HOURS

PEAK OUTFLOW IS 268. AT TIME 15.17 HOURS

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO 1 .35	RATIO 2 .36	RATIO 3 .07	RATIO 4 .08	RATIO 5 .09	RATIO 6 .10	RATIO 7 .11	RATIO 8 .12	RATIO 9 .13
HYDROGRAPH AT	10006	.65	1	360.	432.	504.	576.	648.	721.	793.	865.	937.
		(1.68)		(10.20)(	12.24)(	14.28)(	16.32)(	18.36)(	20.40)(	22.44)(	24.48)(	26.52)
ROUTED TO	10006	.65	1	62.	75.	-1.	106.	121.	141.	183.	226.	268.
		(1.68)		(1.75)(	2.12)(	2.56)(	3.00)(	3.44)(	3.98)(	5.19)(	6.40)(	7.60)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	806.00	806.00	809.40
STORAGE	147.	147.	201.
OUTFLOW	0.	0.	135.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.05	807.26	0.00	170.	62.	0.00	17.25	0.00
.06	807.51	0.00	181.	75.	0.00	17.25	0.00
.07	807.74	0.00	186.	91.	0.00	17.17	0.00
.08	807.97	0.00	191.	106.	0.00	17.17	0.00
.09	808.20	0.00	196.	121.	0.00	17.17	0.00
.10	808.42	.02	202.	141.	1.25	17.08	0.00
.11	808.63	.13	206.	165.	2.42	16.33	0.00
.12	808.84	.24	208.	224.	2.67	16.25	0.00
.13	809.06	.36	213.	265.	2.83	16.17	0.00